A BIOCHEMIC BASIS FOR THE STUDY OF PROBLEMS OF TAXONOMY, HEREDITY, EVOLUTION, ETC., WITH ESPECIAL REFERENCE TO THE STARCHES AND TISSUES OF PARENT-STOCKS AND HYBRID-STOCKS AND THE STARCHES AND HEMOGLOBINS OF VARIETIES, SPECIES, AND GENERA.

BY

EDWARD TYSON REICHERT, M.D., Sc.D.

Professor of Physiology in the University of Pennsylvania
Research Associate of the Carnegie Institution of Washington

IN TWO PARTS

PART II

WASHINGTON, D. C.

PUBLISHED BY THE CARNEGIE INSTITUTION OF WASHINGTON

1919

CARNEGIE INSTITUTION OF WASHINGTON
Publication No. 270, Part II

PRESS OF J. B. LIPPINCOTT COMPANY
PHILADELPHIA

TABLE OF CONTENTS

PART I.

PART II.

PREFATORY NOTES.

The laboratory records of the properties of starches that compose this chapter were prepared by two of the author's assistants, Dr. Elizabeth E. Clark and Miss Martha Bunting (see page 22). The work was carried on in accordance with the plans and methods laid down by the writer, and the data here presented are given substantially *verbatim et literatim*, the only material alterations made having been in the elimination of a large volume of seemingly unessential matter and in occasional changes to eliminate ambiguity. These records fall into two natural groups—quantitative and qualitative. The former, as previously stated, and as is evident by the context, are admirably adapted to comparative summarizing, tabulation, and charting; while the latter can be satisfactorily utilized in this way, within reasonable limits of space, to only a very limited degree.

It is a fact of fundamental importance that the quantitative and qualitative records pertaining to the reactions of any given starch with any given reagent may bear no relationship, as, for instance, when the time-reactions are the same but the qualitative reactions differ, and *vice versa*. The quantitative reactions of a given starch with different reagents vary within narrow to very wide limits, depending upon the kind of starch and the kinds of reagents; and the qualitative reactions vary not only quite as markedly, but also exhibit at times peculiarities that are not only not indicated by the quantitative reactions, but which are of great importance in demonstrating singularities in the physico-chemical constitution of the starch. Any such peculiarity may be one that is common to a genus, species, or variety, or that is individual to a parent or its offspring. Moreover, in every kind of starch, whatsoever the plant source, there may be found several histologic types of grains which vary in number and kind in different starches, which types may be distinctive of a genus, species, variety, or individual. Furthermore, as pointed out in the preceding memoir (page 302), the starch of any given plant, and even that composing an individual grain, is not a unit-substance, so that the different types of grains, as well as the individual grains, are each composed of a number of modifications of a given form of starch. As a consequence, the several types of grains, the primary and secondary and tertiary lamellæ, and the different lamellæ of a simple grain, may each exhibit more or less distinctive differences in either or both quantitative and qualitative reactions, and these are apt to be notably conspicuous in the latter.

The quantitative reactions, as shown, offer convincing evidence of the value of the physico-chemical method in the demonstration of the characteristics of starches in relation to genera, species, and varieties, and to parents and offspring; and while the qualitative reactions have received scarcely more than the most casual references, it will be found that they are not less striking and cogent, and in certain respects even more suggestive, valuable and remarkable. Attention is therefore now directed particularly to the latter. Inasmuch as the general reader will likely glance with some degree of hopelessness over the considerable mass of data that represent the qualitative reactions, it is suggested that a critical perusal of the records that pertain to a single set of parents and progeny, such as those of the *Amaryllis-brunsvigia-brunsdonnæ* set, will prove quite an easy and short road to obtaining a good insight into the similarities, dissimilarities, and individualities of each parent and each hybrid, and of the variable and wholly unpredictable ways in which characters and character-phases are or are not transmitted, and new characters appear in the offspring. Obviously, such reading should be supplemented by a study of the quantitative records, and this, in turn, by comparisons of all of the data of different sets of parents and hybrids of the same genus and of different genera, etc. One will not find at present in any other line of investigation so fertile a field for speculation and theory of the mechanisms of heredity in general, and, by no means of the least interest, those concerned in the genesis of new forms.

PART II.

SPECIAL, GENERAL, AND COMPARATIVE LABORATORY DATA OF THE PROPERTIES OF THE STARCHES AND OF THE TISSUES OF PARENT-STOCKS AND HYBRID-STOCKS.

By EDWARD TYSON REICHERT, M.D., Sc.D.

CHAPTER VIII.

1. AMARYLLIS—BRUNSVIGIA.

The genus *Amaryllis* has in recent years been represented by a single species, *A. belladonna* Linn., a bulbous plant that is native of the Cape of Good Hope, and widely cultivated and popularly known as the belladonna lily. The many other species known as amaryllids have been assigned to other genera, including *Hippeastrum, Crinum, Brunsvigia, Ammocharis, Lycoris, Nerine, Sternbergia, Vallota, Zephyranthes,* and *Sprekelia;* but even now many of them, especially the forms of *Hippeastrum*, are known and marketed as forms of *Amaryllis.*

The genus *Brunsvigia* includes, according to Baker, 9 or possibly 10 species of South American bulbous plants. As many as 5 of these have been classed as amaryllids.

Starches were obtained from *Amaryllis belladonna* Linn. (*A. rosea* Lam., *A. pudica* Gawl., *Coburgia belladonna* Herb.), *Brunsvigia josephinæ* Gawl. (*Amaryllis josephinæ* Red., *A. josephinæ* Herb., *A. griffiana* Herb.), and the hybrids *Brunsdonna sanderæ alba* and *Brunsdonna sanderæ.* The specimens of *A. belladonna* and *B. josephinæ* were obtained from C. G. Van Tubergen, Jr., Haarlem, Holland, and those of the hybrids from the growers, Sander and Sons, St. Albans, England. The starch of another hybrid, *Brunsdonna tubergeni,* offspring from the same species, was also studied. The specimens were obtained from the grower, C. G. Van Tubergen, Jr. This hybrid differs materially from the *Brunsdonnæ* and is doubtless a product of a reciprocal cross. Notes pertaining thereto will be found in the form of an appendix to the *Amaryllis-Brunsvigia-Brunsdonna* section in Chapter III, Part I, page 37.

1. Starches of Amaryllis belladonna, Brunsvigia josephinæ, Brunsdonna sanderæ alba, and B. sanderæ.

Amaryllis belladonna (Seed Parent).

(Plate 1, figs. 1 and 4; Charts D 1 to D 21.)

Histologic Properties.

In *form* the grains are usually simple and isolated. No aggregates are observed and only an occasional compound grain which usually consists of two small components, each with its own hilum and a few circular lamellæ situated at the proximal end of a rather broad ovoid-shaped grain. The grains are usually regular in form, and such irregularities as occur are owing to the following causes: (1) A greater broadening of the lamellæ on one side than on the other, so that the grain is somewhat distorted in form; (2) the occurrence of secondary sets of lamellæ whose longitudinal axes are at an angle to the longitudinal axis of the primary set; (3) protuberances, which may be small and rounded, from the proximal end or from the sides; (4) a slight deviation of the longitudinal axis, usually at the distal end. The conspicuous forms are elongated elliptical with both ends rounded or with flattened distal end; rather elongated ovoid and pure ovoid. There are also nearly round, and occasionally triangular with rounded angles, and pyriform grains. The grains are not flattened.

The *hilum* is a small, round, moderately distinct and not very refractive spot. It is usually not fissured, but when fissures occur, they appear as either small, straight, transverse, or longitudinal lines, with very small fissures branching out from them or oblique lines radiating from a central cavity. The hilum is eccentric from 0.27 to 1.16, usually 0.26, of the longitudinal axis.

The *lamellæ* are usually distinct and rather fine; when near the hilum they are continuous and circular or oval; the rest appear to be discontinuous and have the form of the outline of the grain. Often one very broad, refractive lamella separates the grain into two parts, which lamellæ may be located at any position from the upper fourth to lower fourth of the grain. The finer lamellæ are divided into bands of different widths by a variable number of less fine and more refractive lamellæ. The lamellæ at the distal end are often more distinct and less fine than those of the rest of the grain, but this is not invariably the case. The number of lamellæ counted on the larger grains varies from 24 to 50, commonly 42.

The *size* varies from the smaller grains which are 10 by 8μ, to the larger which are 62 by 40μ in length and breadth. The common size is 46 by 30μ.

Polariscopic Properties.

The *figure* varies from centric to very eccentric, mostly the latter, hence the mean is very eccentric, and it is distinct and clean-cut. The lines are generally fine with slight broadening at the margin and usually intersect obliquely. They are commonly straight but occasionally bent. Compound figures are rare.

The *degree of polarization* is very high (value 97). There is very little variation either among the individual grains, a few being extremely high, or in the same aspect of a given grain.

With *selenite* the quadrants are sharply defined, generally unequal in size, and usually regular in shape. The colors are generally pure, the orange sometimes showing slight impurity as a reddish or brownish tinge at the point of intersection. A greenish tinge is found to both the blue and the orange of a few grains which have an extremely high degree of polarization.

Iodine Reactions.

With 0.25 per cent Lugol's solution most of the grains immediately color a moderate blue-violet with a few moderately deep (value 55), which deepens quickly to moderate to deep, becoming more bluish in tint. With 0.125 per cent Lugol's solution the grains color very lightly blue-violet which deepens very little, still remaining very light. After heating in water until all the grains are gelatinized and then adding 2 per cent Lugol's solution, most of the *grains* color a moderately deep to very deep indigo-blue; some grains have a reddish tint and thus

become a deep purple, the mean is deep, the *solution* becomes a deep indigo-blue. If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution most of the *grain-residues* color a deep to very deep indigo-blue, but a few have a reddish tint, only a few are colored very deep; the *capsules* color a light old-rose to deep heliotrope, mean moderate to deep in color. The *solution* becomes a very deep indigo-blue.

Aniline Reactions.

With *gentian violet* the grains stain very lightly to lightly at once, and in half an hour they become moderate with a few deep (value 55), also some unevenness in color of the individual grains.

With *safranin* the grains stain very lightly at once and in half an hour they become moderate with a few deep (value 55) in color. The same unevenness in color of the individual grains is noted as when treated with gentian violet.

Temperature Reactions.

The majority of the grains are gelatinized at 70° to 71° C., and in all but the distal end of rare grains at 72.5° to 73° C., mean 72.75°.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins at once in a few grains. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 12 per cent of the total starch in 5 minutes; in about 41 per cent of the grains and 50 per cent of the total starch in 15 minutes; in about 77 per cent of the grains and 85 per cent of the total starch in 30 minutes; in about 84 per cent of the grains and 92 per cent of the total starch in 45 minutes; in about 92 per cent of the grains and 96 per cent of the total starch in 60 minutes. (Chart D 1.) A bubble appears at the hilum which is quite persistent and remains small until the approach of the gelatinized area; it may then expand a little previous to expulsion. The lamellæ do not become any more distinct. A refractive border is found which envelops the entire margin; it broadens as the process continues, but always remains wider at the distal margin. Gelatinization usually starts at the distal margin but is quickly followed at the proximal end of most grains; the process is generally accompanied by considerable distention and distortion of the capsule. Irregular channels may form previous to complete gelatinization in the more resistant area of a few grains; in such grains gelatinization may be completed in the less refractive area before the process is finished in the more refractive border. The most resistant starch is generally found in a band just distal to the hilar region. The gelatinized grains are much swollen and distorted, so that they do not resemble the untreated grain.

The reaction with *chromic acid* begins in a few grains in half a minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 15 per cent of the grains and 70 per cent of the total starch in 15 minutes; in about 50 per cent of the grains and 88 per cent of the starch in 20 minutes; in about 65 per cent of the grains and 95 per cent of the total starch in 25 minutes; and in about 99 per cent of the grains and 99 per cent of the total starch in 30 minutes; all are gelatinized in 35 minutes. (Chart D 2.)

The reaction with *pyrogallic acid* begins in a few grains in half a minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 17 per cent of the grains and 40 per cent of the total starch in 15 minutes; in about 35 per cent of the grains and 75 per cent of the total starch in 30 minutes; in about 35 per cent of the grains and 85 per cent of the total starch in 45 minutes; in about 35 per cent of the grains and 90 per cent of the total starch in 60 minutes. A small area at the distal end is very resistant. (Chart D 3.)

The reaction with *nitric acid* begins in all the grains immediately. Complete gelatinization occurs in about 50 per cent of the grains and total starch in half a minute; in about 95 per cent of the grains and of the total starch in 1 minute; in about 99 per cent of the grains and total starch in 2 minutes; in about 99 per cent of the grains and of the total starch in 3 minutes. Very slight progress in 5, 10, and 15 minutes, but complete gelatinization of all of the grains in 30 minutes. (Chart D 4.) A bubble appears at the hilum which expands considerably; in some grains it is very quickly expelled, while in others it less rapidly disappears and moves distalward through the mesial region. The lamellæ become more distinct, and a narrow refractive border is formed. Gelatinization advances rapidly through the mesial region from the hilum to the distal margin; a few lamellæ at the distal margin may become striated and disorganized into refractive granules previous to gelatinization. Well-defined fissures do not usually appear during the progress of the reaction. The most resistant area is the narrow border at the distal margin.

The gelatinized grains are swollen and slightly to considerably distorted; the distortion is greater at the distal margin and rarely a few refractive granules may remain a short distance above the distal margin.

The reaction with *sulphuric acid* begins immediately in all of the grains, and many are completely gelatinized in half a minute. Complete gelatinization occurs in about 95 per cent of the grains and of the total starch in 1 minute; in about 98 per cent of the grains and of the total starch in 1.25 minutes; and in all the grains in 1.5 minutes. (Chart D 5.)

The reaction with *hydrochloric acid* begins immediately in all of the grains. Complete gelatinization occurs in about 50 per cent of the grains and the total starch in 15 seconds; in about 95 per cent of the grains and total starch in 1 minute; and in over 99 per cent of the grains and total starch in 2 minutes. There is little change in 5 minutes, but gelatinization is complete in 10 minutes. (Chart 6.)

The reaction with *potassium hydroxide* is complete in all of the grains in 15 seconds. (Chart D 7.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 22 per cent of the grains and 89 per cent of the total starch in 5 minutes; in about 42 per cent of the grains and 96 per cent of the total starch in 15 minutes; in about 58 per cent of the grains and 98 per cent of the total starch in 30 minutes; in about 69 per cent of the grains and 99 per cent of the total starch in 45 minutes; in about 73

per cent of the grains and over 99 per cent of the total starch in 60 minutes. (Chart D 8.) The hilum swells rapidly and a small bubble is rarely detected thereat. The lamellæ become more distinct, the definition not usually being sharp in an area of from one-third to one-half of the distance between the hilum and distal margin. The lamellæ of the remainder of the grain become sharply defined at once with the exception of a narrow refractive distal border found on some grains in which the definition is more gradual. Two delicate fissures, usually but little branched, proceed from the hilum distalwards. Gelatinization advances rapidly in many grains at the same time, and while but a few may be completely gelatinized, yet the reaction has progressed in so many that the total gelatinization reaches a high percentage very quickly. The reaction advances rapidly through the mesial region to within a short distance from the distal margin, a few lamellæ at this margin forming the most resistant starch. The lamellæ are usually disorganized without the appearance of prominent refractive granules; in some grains, however, a few such granules may appear in the area around the hilum and at a short distance above the distal margin. The gelatinized grains are much swollen and usually but little distorted, the distortion when present being greater at the distal margin. In some grains a few lamellæ at the distal end may remain ungelatinized and occasionally a few refractive granules may resist the reaction.

The reaction with *potassium sulphocyanate* begins in all the grains at once, and a few are completely gelatinized in 1 minute. Complete gelatinization occurs in about 22 per cent of the grains and 80 per cent of the total starch in 5 minutes; in about 43 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 61 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 69 per cent of the grains and over 99 per cent of the total starch in 45 minutes; in about 78 per cent of the grains and over 99 per cent of the total starch in 60 minutes. (Chart D 9.)

The hilum swells rapidly and usually no bubble is detected thereat, but occasionally a bubble is present which expands to considerable size and is then gradually expelled. The lamellæ quickly become a little more sharply defined, the variations in refractivity of these structures in the untreated grain being accentuated. A narrow refractive band at the distal margin, occasionally present in the untreated grain, becomes more sharply defined. Two delicate plume-like fissures usually proceed distalwards from the hilum, but in some grains one much deeper and larger branching fissure may form and gelatinization proceeds from the hilum along the course of such fissures. Occasionally the area around the hilum seems more resistant and then short radiating fissures appear, especially towards the proximal end and sides nearby, the plume-like fissures in such grains also being present. The lamellæ are frequently disorganized without the appearance of refractive granules, but when the fissures are very deep, scattered refractive granules may appear in the mesial region, and very rarely marginal granules in linear arrangement may follow deep striation of this area. Occasionally the hilum swells more slowly and short radiating fissures proceed therefrom, a cluster of quite refractive granules appearing in this after the disorganization of the lamellæ. The most resistant starch is located in a small area at the distal margin, the lamellæ at this point often become striated and sharply defined, but sometimes this point is homogeneously refractive.

The gelatinized grains are much swollen and usually but slightly distorted, though occasionally considerable distortion appears at the distal margin. At the end of the experiment (60 minutes) refractive granules rarely remain, but a small area of ungelatinized starch is found at the distal margin of some grains. Many of the gelatinized grains bear a general resemblance to the untreated grains.

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 50 per cent of the grains and 90 per cent of the total starch in 1 minute; in about 80 per cent of the grains and 97 per cent of the total starch in 3 minutes; in about 90 per cent of the grains and 98 per cent of the total starch in 5 minutes; in about 95 per cent of the grains and over 99 per cent of the total starch in 10 minutes; in about 98 per cent of the grains and over 99 per cent of the total starch in 15 minutes. (Chart D 10.)

The reaction with *sodium hydroxide* begins immediately and many are gelatinized in 1 minute. Complete gelatinization occurs in about 50 per cent of the grains and 97 per cent of the total starch in 3 minutes; in about 75 per cent of the grains and over 99 per cent of the total starch in 5 minutes; in about 90 per cent of the grains and over 99 per cent of the total starch in 10 minutes; and in about the same in 15 minutes; in about 95 per cent of the grains and over 99 per cent of the total starch in 30 minutes; in about the same in 45 minutes; and in about 97 per cent of the grains and over 99 per cent of the total starch in 60 minutes. (Chart D 11.)

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 15 per cent of the grains and 66 per cent of the total starch in 5 minutes; in about 35 per cent of the grains and 80 per cent of the total starch in 15 minutes; in about 42 per cent of the grains and 84 per cent of the total starch in 30 minutes; about the same at the end of 45 minutes; in about 50 per cent of the grains and 89 per cent of the total starch in 60 minutes. (Chart D 12.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 73 per cent of the grains and 81 per cent of the total starch in 5 minutes; in about 98 per cent of the grains and over 99 per cent of the total starch in 10 minutes; and in all in 15 minutes. (Chart D 13.) A bubble appears at the hilum which is small, expands very little during the reaction, is very persistent, and very rarely located in an enlarged fissure. Rarely, more than one bubble is found at the hilum. A very refractive border is rapidly formed, which spreads around the entire grain, being two or three times as broad at the distal margin as in the remaining border. The lamellæ of the main body of the grain are occasionally demonstrable, and those forming the border gradually become well developed previous to gelatinization. Gelatinization begins in this border at the distal margin and as the reaction proceeds proximally the lamellæ become very refractive and either increase

the width of the border or appear suddenly as a new border; there is not much distortion of the capsule as this border is disorganized and solution of the area gelatinized sometimes quickly follows. When gelatinization from the distal margin has advanced about one-third to one-half of the length of the grain, it starts in most of the grains in the narrow refractive border at the proximal end and advances rapidly towards the hilum, the bubble expands slightly and is gradually expelled as the reaction reaches the hilum, the most resistant part of the grain being a band of about one-third to one-quarter of the length of the grain, which extends entirely across the grain. In a small number of grains gelatinization proceeds almost to the hilum before the reaction at the proximal end has made much progress, leaving only a very narrow area just distal to the hilum at the resistant part of the grain. Gelatinization occurs without the previous formation of either clearly defined fissures or the appearance of refractive granules. The gelatinized grains are much swollen, with more distortion at the proximal than the distal end.

The reaction with *calcium nitrate* begins in some grains immediately. Complete gelatinization occurs in about 48 per cent of the grains and 96 per cent of the total starch in 5 minutes; in about 80 per cent of the grains and 98 per cent of the total starch in 15 minutes; in about 90 per cent of the grains and over 99 per cent of the total starch in 30 minutes; and in about the same percentage of the grains and total starch in 45 and 60 minutes, respectively. (Chart D 14.)

The reaction with *uranium nitrate* begins immediately. Complete gelatinization occurs in about 17 per cent of the grains and 65 per cent of the total starch in 5 minutes; in about 30 per cent of the grains and 91 per cent of the total starch in 15 minutes; in about 52 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 56 per cent of the grains and 96 per cent of the total starch in 45 minutes; and in about 56 per cent of the grains and 96 per cent of the total starch in 60 minutes. (Chart D 15.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 65 per cent of the grains and 98 per cent of the total starch in 5 minutes; and in about 98 per cent of the grains and over 99 per cent of the total starch in 15 minutes. (Chart D 16.)

The reaction with *cobalt nitrate* begins at once. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and in 12 per cent of the total starch in 5 minutes; in about 8 per cent of the grains and 52 per cent of the total starch in 15 minutes; in about 21 per cent of the grains and 74 per cent of the total starch in 30 minutes; in about 26 per cent of the grains and 78 per cent of the total starch in 45 minutes; in about 30 per cent of the grains and 82 per cent of the total starch in 60 minutes. (Chart D 17.) Gelatinization begins at the proximal end and proceeds moderately rapidly at first and later very quickly, leaving an area varying from about half of the grains to a very small portion at the distal margin ungelatinized.

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 18 per cent of the entire number of grains and 78 per cent of the total starch in 5 minutes; in about 42 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 53 per cent of the grains and 93 per cent of the total starch in 30 minutes; slight progress in about 95 per cent of the total starch in 45 minutes; in about 60 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 18.) Gelatinization begins at the proximal end and proceeds rapidly towards the distal margin, practically all of the grains being affected. The small area at the distal margin is very resistant in many grains.

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 20 per cent of the entire number of grains and 73 per cent of the total starch in 5 minutes; in about 43 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about the same percentage of grains and total starch in 30 minutes; in about the same percentage of grains and 95 per cent of the total starch in 45 minutes; and in about 47 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 19.) The reaction begins and proceeds simultaneously in many grains. The process starts at the proximal end and advances towards the distal end, a small area at the distal end being very resistant in a number of grains.

The reaction with *barium chloride* begins in a few grains in half a minute. Complete gelatinization occurs in less than 0.5 per cent of the grains and of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; and about the same percentages in 30 and 45 minutes; and about 0.5 per cent of the grains and 2 per cent of the total starch in 60 minutes. (Chart D 20.)

The reaction with *mercuric chloride* begins immediately in a few grains. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and the total starch in 5 minutes; in about 3 per cent of the grains and 13 per cent of the total starch in 15 minutes; in about 6 per cent of the grains and 16 per cent of the total starch in 30 minutes; in about 10 per cent of the grains and 26 per cent of the total starch in 45 minutes; in about 16 per cent of the grains and 40 per cent of the total starch in 60 minutes. (Chart D 21.)

Brunsvigia josephinæ (Pollen Parent).

Histologic Properties.

(Plate 1, figs. 2 and 5; Charts D 1 to D 21.)

In *form* the grains are usually simple and isolated; but differ from *A. belladonna* in that there are a number of small aggregates usually of from 2 to 4 small grains and occasionally from 12 to 14 grains. Compound grains occur much more frequently than in *A. belladonna* and are more varied in form. They usually consist of two small components, each with its own clearly defined lamellæ; and these two grains are joined by common secondary lamellæ on both sides, but not entirely surrounded by them. This curious compound grain may be in turn surrounded by a number of lamellæ which probably represent a tertiary deposition of starch. There are also doublets and triplets whose components lie at different levels in the inclosing secondary starch formation, and doublets in which a small round grain has become adherent to a large ovoid grain, and both have

been inclosed in a lamellated secondary starch formation. The grains are less regular in form than those of *A. belladonna* and the irregularities are due to the following causes: (1) indentations in the margin of varying depth, number, and distribution, an irregularity not noted in *A. belladonna;* (2) rounded and pointed protuberances, of which there may be one or more from a single grain and which may project from any part of the margin; (3) secondary and tertiary sets of lamellæ whose longitudinal axis is at an angle with that of the primary set. The grains are much more varied in form than those of *A. belladonna* because of the many irregularities, but appear to be derived from the ovoid, elliptical, and lenticular types. The conspicuous forms are broad and slender ovoid, pure ovoid, elliptical and triangular, with slightly or very much rounded angles; also lenticular, dome-shaped, pyriform, nearly round, diamond-shaped, and irregularly polygonal forms. The grains are usually somewhat flattened, differing in this from those of *A. belladonna* which are not flattened.

The *hilum* is a small, round, rather refractive spot which is more distinct than in *A. belladonna;* it is rarely fissured, resembling *A. belladonna.* More than one hilum appears in the compound grains, but each is always surrounded with its own lamellæ except in the case of a few compounds which have four or more hila for which separate lamellæ can not be demonstrated. The hilum is either centric, or eccentric from 0.48 to 0.2 usually of 0.35 of the longitudinal axis. It is usually less eccentric than in *A. belladonna.*

The *lamellæ* are not so fine as and are more distinct than those of *A. belladonna.* Immediately around the hilum they are circular and regular, but the rest tend to be very irregular in form and often do not follow the contour of the outline of the grain unless near the margin. In the latter respects they differ from those of *A. belladonna,* which are regular and follow the form of the outline of the grain. In the compound grains there are two and sometimes three sets of lamellæ, usually separated from one another by broad refractive spaces, which separation represents as many different periods of starch formation. The number counted on the larger grains varies from 18 to 30, usually 24. The average number on the grains is much less than in *A. belladonna.*

In *size* the grains vary from the smaller which are 10 by 8μ to the larger broad forms which are 42 by 60μ and 54 by 60μ in length and breadth, and the larger narrow forms which are 50 by 36μ and 64 by 54μ in length and breadth. The common sizes are 40 by 40μ and 34 by 28μ. The grains are on the average smaller than those of *A. belladonna* but broader in proportion to length, and the larger grains are nearly the same length and, as a rule, broader.

Polariscopic Properties.

The *figure* varies from centric to very eccentric, many moderately eccentric, the mean eccentric, it being much less eccentric than in *A. belladonna;* the figure varies from moderately distinct to distinct, the mean less distinct than in *A. belladonna.* The lines vary from fine to coarse, the mean moderately fine, coarser than in *A. belladonna.* The lines intersect either at right angles, or obliquely, or are arranged as a median line with bisected ends, more frequently with oblique intersection; much more varied, with the mean less oblique than in *A. belladonna.* The lines in the majority of the figure are straight with broadening at the margin, but are often either bent or bisected. Distortion and bisection are much more frequent than in *A. belladonna.* Compound figures moderately frequent, much more frequent than in *A. belladonna.*

The *degree of polarization* varies from moderately high to very high (value 85), the majority being high; the mean is considerably lower than in *A. belladonna.* Variation occurs not only in the individual grains but frequently in the same aspect of a given grain, much more than in *A. belladonna.*

With *selenite* the quadrants vary from sharp to poorly defined, the mean being much less sharp than in *A. belladonna.* They are usually unequal in size and often irregular in shape, much more irregular in shape than in *A. belladonna.* The blue is generally pure, though a variation in brilliancy of the same quadrant is often present; the yellow is frequently impure in a part of the quadrant, due to either a brownish or an orange color, which is found at the point of intersection of the quadrants and diffuses over considerable of the quadrant, this impurity evidently being due to the variation in the degree of polarization in the quadrants. An impurity of both colors due to a greenish tinge is sometimes present, though of less frequency than in *A. belladonna.*

Iodine Reactions.

With an 0.25 Lugol's solution the grains color a moderate to deep (value 60) blue with a slight reddish tint, a little deeper and more bluish than in *A. belladonna,* the color deepens quickly to deep, becoming more bluish in tint. With 0.125 Lugol's solution the grains color very light blue with slight reddish tint, but a little deeper than in *A. belladonna;* it deepens very little. After heating in water until the grains are gelatinized, and then adding 2 per cent Lugol's solution, the *grains* color light blue to very deep blue, many with a reddish tint becoming heliotrope; mean is moderate to deep; there is a greater variation in depth with the mean lighter, as well as more reddish than in *A. belladonna;* the *solution* becomes a deep blue, somewhat deeper and not quite so pure in color as in *A. belladonna.* If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution the *grain-residues* color a deep to very deep blue, many with a reddish tint; a greater number of the very deep, mean deep to very deep, deeper and more of reddish tint than in *A. belladonna.* The *capsules* color a light old-rose to deep amethyst, more of the deep, hence the mean is moderate to deep (value 65), somewhat deeper and more reddish in tint than in *A. belladonna.* The *solution* becomes a very deep indigo blue, slightly deeper than in *A. belladonna.*

Aniline Reactions.

With *gentian violet* the grains stain lightly at once, a little deeper than in *A. belladonna;* in half an hour the grains become moderate to deep in color (value 57), slightly deeper than in *A. belladonna.* There is some slight unevenness in the individual grains, but only rare grains are deep in color.

With *safranin* the grains stain very lightly at once, about the same as in *A. belladonna,* and in half an hour they become moderate in color, a little lighter than in *A. belladonna* (value 53); there is less variation in depth since those staining deeply are much less numerous than in *A. belladonna.*

Temperature Reactions.

The majority of the grains are gelatinized at 65° to 66° C., and of all but rare grains at 70° to 72° C., mean 71° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins at once in a few. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 9 per cent of the total starch in 5 minutes; in about 33 per cent of the grains and 46 per cent of the total starch in 15 minutes; in about 65 per cent of the grains and 74 per cent of the total starch in 30 minutes; in about 69 per cent of the grains and 78 per cent of the total starch in 45 minutes; in about 74 per cent of the grains and 82 per cent of the total starch in 60 minutes. (Chart D 1.) A bubble appears at the hilum which, though more frequently small, expands to greater size in many more grains than in *A. belladonna.* The cleft present in a number of untreated grains becomes much enlarged and very refractive, such clefts being rarely observed in *A. belladonna.* The definition of the lamellæ becomes sharper in many more grains than in *A. belladonna.* A refractive border of a similar character is formed, but it is not so clearly defined from the rest of the grain as in *A. belladonna.* In some grains gelatinization begins and proceeds as in *A. belladonna,* but additional methods are more commonly observed. In the larger number of grains gelatinization begins at both ends of the distal margin and extends bilaterally towards the proximal end, which is often gelatinized previous to the distal margin between the limiting corners, but finally the entire grain is gelatinized except a small area around the hilum, which is the last starch to undergo the reaction. Gelatinization not infrequently starts at one corner of the distal margin, if this is quite prominent, and later follows the course above described. Irregular fissures appear more frequently in the grains than in *A. belladonna;* and such clefts are more often found in the border, sometimes cutting off a small area which gelatinizes independently. In other grains a number of deep short fissures may extend inwards through the refractive border; such clefts were not observed in *A. belladonna.* The process of gelatinization is accompanied by greater distortion and distention than in *A. belladonna.* The gelatinized grains are much swollen and distorted, even more so in some grains than in *A. belladonna;* hence they do not resemble the form of the untreated grains.

The reaction with *chromic acid* begins in a few grains in 30 seconds. Complete gelatinization occurs in about 20 per cent of the grains and 30 per cent of the total starch in 5 minutes; in about 40 per cent of the grains and 85 per cent of the starch in 15 minutes; in about 77 per cent of the grains and 98 per cent of the total starch in 20 minutes; rare traces of outline in over 99 per cent of the grains and the total starch in 25 minutes; and a very slight trace of outline is left in 30 and 35 minutes. (Chart D 2.)

The reaction with *pyrogallic acid* begins in a few grains in 30 seconds. Complete gelatinization occurs rapidly, and in about 32 per cent of the total starch in 5 minutes; in about 64 per cent of the total starch in 15 minutes; in about 98 per cent of the total starch in 30 minutes; in about 98 per cent of the total starch in 45 minutes; and over 99 per cent of the total starch in 60 minutes. (Chart D 3.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 70 per cent of the grains and 80 per cent of the total starch in 1 minute; in about 80 per cent of the grains and 93 per cent of the total starch in 2 minutes; in about 84 per cent of the grains and 95 per cent of the total starch in 3 minutes; in about 84 per cent of the grains and 98 per cent of the total starch in 5 minutes; in over 99 per cent of the grains and the total starch in 10 minutes. Gelatinization is not entirely completed in 15, 30, and 60 minutes, respectively. (Chart D 4.) A small bubble may appear at the hilum, which is more frequently inclosed in a fissure, expands less and is more transient than in *A. belladonna.* The lamellæ become very sharply defined and a refractive border is formed; the definition of the lamellæ is sharper and the border more prominent and broader than in *A. belladonna;* definite fissures occur which are deep, much branched, and varied in character in relation to shape of grain; the fissures are very much more frequent and sharply defined than in *A. belladonna.* Gelatinization in the majority of grains is much more rapid in the distal border and may spread around the entire grain which may become completely gelatinized and much ruffled, or if the outermost lamella is quite resistant the border may become much swollen and bounded by a narrow layer of linearly arranged, refractive granules. The lamellæ of the main body of such grains is disorganized into large refractive granules which frequently resist complete gelatinization. In a minority of grains the reaction generally advances more rapidly through the mesial region, the distal border becoming densely striated and broken into linearly arranged granules previous to gelatinization; or the reaction may start at two ends and advance towards the center of elongated grains with nearly centric hilum. This reaction is more varied and the methods of gelatinization not similar to that observed in *A. belladonna.* The refractive granules are very much more commonly observed, are much more numerous and larger in a given grain, and the fissures much deeper, more common, and more varied in character than in *A. belladonna.*

The gelatinized grains are much swollen and distorted and usually contain a few to many refractive granules which are usually located around the hilum or at the proximal end. The grains are much more distorted than in *A. belladonna* and the most resistant starch is located at or near the proximal end.

The reaction with *sulphuric acid* begins immediately and many grains are gelatinized in half a minute. Gelatinization is complete in about 87 per cent of the grains and 99 per cent of the total starch in 2 minutes and in over 99 per cent of the grains and total starch in 5 minutes. (Chart D 5.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 50 per cent of the grains and total starch in half a minute, and 90 per cent of the grains and total starch in 1 minute; in about 95 per cent of the grains and total starch in 2 minutes; and 99 per cent of the grains and total starch in 3 minutes. The remainder of the margin of a few grains and rare small grains may be still ungelatinized in 5 and 15 minutes. (Chart D 6.)

The reaction with *potassium hydroxide* begins immediately and many grains are gelatinized in 15 seconds. Complete gelatinization occurs in about 75 per cent of the grains and 98 per cent of the total starch in 1 minute; in about 90 per cent of the grains and over 99 per cent of the total starch in 5 minutes, and in all in 15 minutes with the exception of a resistant border in a few grains. (Chart D 7.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 55 per cent of the grains and 85 per cent of the total starch in 5 minutes; in about 75 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 89 per cent of the grains and 98 per cent of the total starch in 30 minutes; in about 89 per cent of the grains and 99 per cent of the total starch in 45 minutes; in about 90 per cent of the grains and over 99 per cent of the total starch in 60 minutes. (Chart D 8.)

The hilum when unfissured swells less rapidly and a bubble is less frequently present than in *A. belladonna*. In many grains fissures are present which are enlarged and become very refractive, the refractivity being lost without the appearance of a bubble; such fissures were not observed in *A. belladonna*. The lamellæ become more sharply defined, the definition often not being so sharp near the hilum; the lamellæ are much more distinct over a larger part of the grain than in *A. belladonna.* The fissures are deeper, more branched, and more varied in character than in *A. belladonna*. There are usually two fissures which extend distalwards, or to both ends of elongated grains with centric or slightly eccentric fissure; and in addition many short fissures may radiate from the hilum; these numerous radiating fissures were not observed in *A. belladonna*. The method of gelatinization is much more varied than in *A. belladonna.* It more frequently proceeds quickly through the mesial region from the hilum towards the distal margin, accompanied by the appearance of a mass of very refractive granules, a narrow band at the distal margin often becoming completely gelatinized previous to a few lamellæ above this band; these resistant lamellæ become deeply striated and disorganized into linear refractive granules which may or may not become completely gelatinized. In elongated grains with centric or nearly centric hilum the reaction is completed more quickly at both ends, a narrow band extending on either side of the hilum being the most resistant starch. In other grains a narrow border around the entire grain may be completely gelatinized, while many refractive granules inclosed by the border remain ungelatinized. The resistant starch varies in position, sometimes being located in a narrow border at the proximal end, sometimes around the entire grain, or in a small area at or near the distal margin, and again at either side of the hilum in long slender grains with a centric or nearly centric hilum. The starch is disorganized much more frequently with the appearance of refractive granules which are much more refractive than in *A. belladonna,* and the resistant starch is much more varied in position. The reaction is much varied in its rapidity in the different grains, much more varied than in *A. belladonna.* The gelatinized grains are slightly to considerably distorted, much more so than in *A. belladonna.* A few to many refractive granules usually remain at the end of the reaction, much more frequently than in *A. belladonna.*

The reaction with *potassium sulphocyanate* begins immediately, and a few grains are gelatinized in half a minute. Complete gelatinization occurs in about 36 per cent of the grains and 63 per cent of the total starch in 5 minutes; in about 43 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 61 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 92 per cent of the grains and over 99 per cent of the total starch in 45 minutes; and in about 97 per cent of the grains and over 99 per cent of the total starch in 60 minutes. (Chart D 9.)

The hilum, in a few grains of similar shape to those of *A. belladonna,* swells much more slowly and a bubble is even less frequently observed. In most of the grains, a fissure which is often thorn-like becomes much enlarged, followed by the rapid gelatinization of the surrounding area; such a fissure was not observed in *A. belladonna.* The lamellæ become more sharply defined and a refractive border present in the untreated grain becomes more accentuated; the definition is sharper, the variation in the refractivity of the lamellæ of an individual grain greater, and the appearance of the refractive border is more common than in *A. belladonna.* These points are also more marked in the untreated grain than in *A. belladonna.* Fissures appear of a similar character to those described in *A. belladonna,* but deeper and more profusely branched. In addition to the fissures above named, thorn-like fissures often appear at the hilum, the main divisions towards the distal margin sometimes becoming branched and plume-like, and not uncommonly a few short, very deep fissures are scattered through the most brilliant lamellæ. The lamellæ around the hilum and through the mesial region for a short distance are disorganized with the appearance of irregularly massed, very refractive granules; the most refractive lamellæ become either deeply striated or even fissured, in the former breaking into linearly arranged granules, while in the latter fragments may form which appear sometimes to be composed of clusters of granules and may have a serrate appearance with the point directed towards the proximal end. These fragments and granules are much more brilliant and more commonly observed than in *A. belladonna.* In many grains the large, brilliant, linear granules or fragments appear towards the distal margin and are bounded by a border of completely gelatinized starch of varying widths; the granules at the proximal end and sides are smaller, but linearly arranged and very brilliant; these are less frequently bounded by the gelatinized border than at the distal margin, although it is not uncommon to find such a border; this border surrounding a row of slightly refractive granules at the

distal margin is very rarely observed, while such a border and granules have not been noted in *A. belladonna.*

The gelatinized grains are much swollen and considerably distorted, showing much greater distortion than is commonly found in *A. belladonna.* Refractive granules are present in most of the grains, often bordering either the entire margin or forming a lining to a hyaline border, as already described. The granules are much more common and the proximal end and sides nearby are more resistant than in *A. belladonna;* yet in a few grains where the course of gelatinization is about the same the resistant area at the distal margin may be found as described in *A. belladonna.*

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 28 per cent of the grains and 65 per cent of the total starch in 1 minute; in about 47 per cent of the grains and 76 per cent of the total starch in 3 minutes; in about 50 per cent of the grains and 83 per cent of the total starch in 5 minutes; in about 55 per cent of the grains and 86 per cent of the total starch in 10 minutes; in about 57 per cent of the grains and 87 per cent of the total starch in 15 minutes; in about 66 per cent of the grains and 89 per cent of the total starch in 30 minutes; in about 70 per cent of the grains and 90 per cent of the total starch in 45 minutes; and in about 70 per cent of the grains and 91 per cent of the total starch in 60 minutes. (Chart D 10.)

The reaction with *sodium hydroxide* begins immediately and many grains are gelatinized in 1 minute. Complete gelatinization occurs in about 47 per cent of the grains and 75 per cent of the total starch in 3 minutes; in about 50 per cent of the grains and 85 per cent of the total starch in 5 minutes; in about 77 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 80 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 82 per cent of the grains and 97 per cent of the total starch in 45 minutes; in about 92 per cent of the grains and over 98 per cent of the total starch in 60 minutes. (Chart D 11.)

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 26 per cent of the grains and 71 per cent of the total starch in 5 minutes; in about 41 per cent of the grains and 85 per cent of the total starch in 15 minutes; in about 48 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 53 per cent of the grains and 93 per cent of the total starch in 45 minutes; in about 54 per cent of the grains and 96 per cent of the total starch in 60 minutes. (Chart D 12.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 21 per cent of the grains and 40 per cent of the total starch in 5 minutes; in about 68 per cent of the grains and 78 per cent of the total starch in 10 minutes; in about 88 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 97 per cent of the grains and 99 per cent of the total starch in 20 minutes; over 99 per cent of the grains and total starch gelatinized in 25 minutes. (Chart D 13.) A small bubble appears at the hilum in most of the grains, but it is more frequently inclosed within a fissure at the hilum and in such grains expands to greater size than in *A. belladonna.* Two or more bubbles appear with considerably more frequency at the hilum than in *A. belladonna.* A refractive border is quickly formed but is not so clearly defined from the main body of the grain, nor does it appear to continuously broaden in advance of gelatinization as in *A. belladonna.* The lamellæ are sharply defined over a greater area of the grain and also in more grains than in *A. belladonna.* Gelatinization at the distal margin in the majority of grains does not advance nearly so far from this margin as in *A. belladonna* before the reaction starts either at the proximal end or extends through the narrow border surrounding the entire grain. The most resistant area is generally a band extending across the grain which is nearer the distal margin than is usually the case in *A. belladonna.* Gelatinization may begin at one or both corners, limiting the distal margin, or at any abrupt corner nearer the proximal end; the process is accompanied in all grains by considerable distention and distortion of the capsule. The method of gelatinization is more varied and the distortion accompanying the process much greater than in *A. belladonna.* A series of small fissures extending proximalwards from the distal margin is frequently observed and a network of fissures may form in the most resistant area of the grain previous to gelatinization; such fissures were not observed in *A. belladonna.* The reaction is much more rapid in some grains than in others, showing a much greater variation than in *A. belladonna.* The gelatinized grains are swollen as in *A. belladonna,* but are much more distorted and partial gelatinization of the grains is not so rapid as in *A. belladonna.*

The reaction with *calcium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 28 per cent of the grains and 60 per cent of the total starch in 5 minutes; in about 48 per cent of the grains and 76 per cent of the total starch in 15 minutes; in about 60 per cent of the grains and 84 per cent of the total starch in 30 minutes; in about 60 per cent of the grains and 87 per cent of the total starch in 45 minutes; and in about 63 per cent of the grains and 90 per cent of the total starch in 60 minutes. (Chart D 14.)

The reaction with *uranium nitrate* begins in some grains immediately. Complete gelatinization occurs in over 15 per cent of the grains and 55 per cent of the total starch in 5 minutes; in about 43 per cent of the grains and 77 per cent of the total starch in 15 minutes; in about 54 per cent of the grains and 84 per cent of the total starch in 30 minutes; in about 66 per cent of the grains and 90 per cent of the total starch in 45 minutes; and in about 66 per cent of the grains and 93 per cent of the total starch in 60 minutes. (Chart D 15.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 48 per cent of the grains and 73 per cent of the total starch in 5 minutes; in about 66 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 88 per cent of the grains and 97 per cent of the total starch in 30 minutes; in about 91 per cent of the grains and 98 per cent of the total starch in 45 minutes; in about 93 per cent of the grains and over 99 per cent of the total starch in 60 minutes. (Chart D 16.)

The reaction with *cobalt nitrate* begins immediately. Complete gelatinization occurs in about 8 per cent of the entire number of grains and 16 per cent of the total starch in 5 minutes; in about 25 per cent of the grains and 54 per cent of the total starch in 15 minutes; in about

37 per cent of the grains and 67 per cent of the total starch in 30 minutes; in about 42 per cent of the grains and 71 per cent of the total starch in 45 minutes; in about 50 per cent of the grains and 75 per cent of the total starch in 60 minutes. (Chart D 17.) Gelatinization proceeds along the courses of the fissures, many of the grains becoming completely gelatinized quite rapidly. The entire margin at first and finally that of the proximal end are usually the most resistant parts of the grain.

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 17 per cent of the grains and 52 per cent of the total starch in 5 minutes; in about 35 per cent of the grains and 75 per cent of the total starch in 15 minutes; in about 45 per cent of the grains and 79 per cent of the total starch in 30 minutes; in about 50 per cent of the grains and 84 per cent of the total starch in 45 minutes; in about 58 per cent of the grains and 88 per cent of the total starch in 60 minutes. (Chart D 18.) The process of gelatinization is more varied in this species than in *A. belladonna,* and the grains are either completely gelatinized or much less quickly affected. In some grains gelatinization begins at the distal end accompanied by extension of the capsule, while in others it proceeds through the mesial portion along the course of deep fissures, the distal end being ultimately gelatinized before the proximal end and sides nearby.

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 19 per cent of the entire number of grains and 35 per cent of the total starch in 5 minutes; in about 48 per cent of the grains and 65 per cent of the total starch in 15 minutes; in about 56 per cent of the grains and 80 per cent of the total starch in 30 minutes; in about 64 per cent of the grains and 86 per cent of the total starch in 45 minutes; and about the same in 60 minutes. (Chart D 19.) The reaction begins and proceeds rapidly through a number of entire grains, while others are but little affected. Deep fissures are formed and the process proceeds along these; in some grains the entire margin is quite resistant, in others the distal margin, and in many the proximal end. The process is much more varied than in *A. belladonna.*

The reaction with *barium chloride* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the grains and over 2 per cent of the total starch in 5 minutes; in over 3 per cent of the grains and over 6 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 7 per cent of the total starch in 30 minutes; in over 4 per cent of the grains and 8 per cent of the total starch in 45 minutes; and in about 5 per cent of the grains and 14 per cent of the total starch in 60 minutes. (Chart D 20.)

The reaction with *mercuric chloride* begins in a few grains immediately. Complete gelatinization occurs in about 4 per cent of the entire number of grains and in over 5 per cent of the total starch in 5 minutes; in about 16 per cent of the grains and 20 per cent of the total starch in 15 minutes; in about 24 per cent of the grains and 33 per cent of the total starch in 30 minutes; in about 27 per cent of the grains and 48 per cent of the total starch in 45 minutes; in about 29 per cent of the grains and 60 per cent of the total starch in 60 minutes. (Chart D 21.)

Brunsdonna sanderæ alba (Hybrid).

(Plate 1, fig. 3; Charts D 1 to D 21.)

Histologic Properties.

In *form* the grains are usually simple and isolated, except a few which occur in small aggregates of 2 and 3 components, in this feature resembling *B. josephinæ.* Compound grains occur as frequently as in *B. josephinæ* and are usually the same types as in that starch. There are: (1) Two small components, each with its own lamellæ, and often lying at different levels, and in a large number (7 to 12) of secondary lamellæ; (2) a number of hila in an amorphous-looking mass surrounded by from 4 to 12 secondary lamellæ, a form of grain rarely observed in *B. josephinæ* and never in *A. belladonna;* (3) a small grain adherent to the side or distal end of a larger grain and both inclosed in 4 or 5 secondary lamellæ; (4) a similar grain, as noted above, but consisting of an amorphous-looking mass composed probably of a number of fused small grains adherent to the side or distal end of a larger grain, both being inclosed within from 6 to 12 secondary lamellæ. This last type is noted only in this starch. The grains are usually regular in form as in *A. belladonna,* and such irregularities as occur are due to the same causes as noted under *A. belladonna* and *B. josephinæ,* but the indentations in the margins of the grains noted in *B. josephinæ* are of rare occurrence. The conspicuous forms are elliptical (with both flattened and rounded distal end) and ovoid. There are also, nearly round, triangular with rounded angles, and a few pyriform grains. The grains are not flattened. In form the grains of *Brunsdonna sanderæ alba* are, as a whole, closer to *Amaryllis belladonna* than to *Brunsvigia josephinæ,* but in certain respects the reverse.

The *hilum* is a small, round, not very distinct spot, not so distinct as in either parent, but nearer to that in *A. belladonna.* It is, apparently, never fissured. The range of eccentricity is from 0.46 to 0.13, usually 0.26 of the longitudinal axis. In the character of the hilum *B. sanderæ alba* more closely resembles *A. belladonna* than *B. josephinæ.*

The *lamellæ* are as distinct but rather finer than those noted under *B. josephinæ* and are usually regular in form as in *B. belladonna,* but in a moderate number of grains they show striking irregularities, as noted under *B. josephinæ.* The number counted on the larger grains varies from 26 to 40, usually about 30. In form and arrangement of the lamellæ *B. sanderæ alba* is closer to *A. belladonna,* but in the average number they are closer to *B. josephinæ.*

The *size* varies from the smaller, which are 10 by 9μ, to the larger, which are 62 by 36μ, rarely 72 by 44μ in length and breadth. The common size is 44 by 34μ. The grains of *B. sanderæ alba* are closer to *A. belladonna* in size and in proportion of length to width than to *B. josephinæ.*

Polariscopic Properties.

The *figure* varies from centric to very eccentric, mostly the later, hence the mean is almost very eccentric, slightly less than *A. belladonna,* but decidedly more than in *B. josephinæ.* The figure is distinct and clean-cut, about the same as *A. belladonna,* but much more so than *B. josephinæ.* The lines are usually fine with slight broadening at the margin, about the same as in *A. bella-*

donna, but much finer than in *B. josephinæ.* They usually intersect obliquely, although some cross at right angles; generally straight, but more frequently bent than in *A. belladonna,* yet not nearly so often as in *B. josephinæ.* Compound figures are occasionally present; they are more numerous than in *A. belladonna,* but less than in *B. josephinæ.*

The *degree of polarization* is very high (value 97), about the same as in *A. belladonna,* but decidedly higher than in *B. josephinæ.* There is very little variation among the individual grains as well as in the same aspect of a given grain, but a somewhat greater range of variation among the individual grains than in *A. belladonna,* although not nearly so great as in *B. josephinæ.*

With *selenite* the quadrants are sharply defined, about the same definition as in *A. belladonna,* but much sharper than in *B. josephinæ.* They are generally unequal in size, though a somewhat greater percentage of those of equal size is present; hence the mean is slightly less unequal than in *A. belladonna,* but it is much more unequal than in *B. josephinæ.* They are generally regular in shape, though slightly more irregularity occurs than in *A. belladonna;* they are much more regular in shape than in *B. josephinæ.* The colors are usually pure, slightly less pure than in *A. belladonna,* but decidedly more pure than in *B. josephinæ.* The impurity due to a greenish tinge of both colors that accompanies extremely high polarization is somewhat more frequent than in *A. belladonna* and much more frequent than in *B. josephinæ.*

In degree of polarization, character of the figure, and appearance with selenite *Brunsdonna sanderæ alba* is closer to *A. belladonna* than to *Brunsvigia josephinæ.*

Iodine Reactions.

With 0.25 Lugol's solution most of the grains color a moderate blue violet (value 55), with a few moderate at once about as reddish in tint as *Amaryllis belladonna,* but more reddish and lighter than in *Brunsvigia josephinæ;* deepens rapidly to moderately deep about the same as in *Amaryllis belladonna,* neither quite so deep nor so bluish as in *Brunsvigia josephinæ.* With 0.125 Lugol's solution the grains color very lightly, about the same as *Amaryllis belladonna,* a little lighter than *Brunsvigia josephinæ,* then deepen gradually, becoming darker than both parents. After heating in water until the grains are gelatinized and then adding 2 per cent Lugol's solution the *grains* color a light to very deep pure indigo-blue, fewer with a reddish tint than in either parent. The mean is deep in color, much nearer the tint but somewhat lighter than in *Amaryllis belladonna:* much less of reddish tint (purer) but somewhat deeper than in *Brunsvigia josephinæ.* The *solution* colors a deep indigo-blue, deeper than in *Amaryllis belladonna,* and of about the same depth but purer in color than in *Brunsvigia josephinæ.* If the preparation is boiled for 2 minutes and then treated with 2 per cent Lugol's solution the *grain-residues* color a light to very deep indigo-blue, a few tinged with red; the mean is moderate to deep in color, lighter than both parents, but nearer the tint of *Amaryllis belladonna* than *Brunsvigia josephinæ.* The *capsules* color a light to deep heliotrope, mean moderate, lighter and less reddish than in the parents. The *solution* colors a very deep indigo-blue, slightly deeper than *Amaryllis belladonna,* about the same as *Brunsvigia josephinæ.* Quantitatively and qualitatively the iodine reactions show a closer relationship to *Amaryllis belladonna* than to *Brunsvigia josephinæ.*

Aniline Reactions.

With *gentian violet* the grains color light to moderate at once, a little deeper than in both parents, and in half an hour they become moderate to deep with only a few of the latter, mean moderately deep (value 60), deeper than in both parents. Variation in depth is found in the individual grains and there are more scattered small grains which stain deeply than in the parents.

With *safranin* the grains stain lightly with a few moderate at once, deeper than in both parents, and in half an hour they become moderate to deep in color (mean moderately deep to deep, value 65), deeper than in both parents.

In the reaction with gentian violet *Brunsdonna sanderæ alba* is closer to *Brunsvigia josephinæ* than to *Amaryllis belladonna.* In the reaction with safranin it is closer to *Amaryllis belladonna* than to *Brunsvigia josephinæ.*

Temperature Reactions

The gelatinization occurs in the majority of grains at 70° to 71° C., and in all but the distal part of rare grains at 71.5° to 73° C., mean 72.25° C. The temperature of gelatinization of *Brunsdonna sanderæ alba* is much closer to *Amaryllis belladonna* than to *Brunsvigia josephinæ.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in a few grains immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 65 per cent of the grains and 75 per cent of the total starch in 15 minutes; in about 93 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 94 per cent of the grains and 97 per cent of the total starch in 45 minutes; in about 96 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 1.)

A small bubble appears at the hilum of most of the grains, and more closely resembles that observed in *Amaryllis belladonna* than in *Brunsvigia josephinæ;* in a small number of grains, however, the bubble becomes quite large previous to expulsion, or a cleft at the hilum may become much enlarged and very refractive in these grains; the resemblance is much less like that of *Amaryllis belladonna* than of *Brunsvigia josephinæ.* The bubble, as a rule, is more transient than in both parents, which may be the cause of the greater rapidity of gelatinization, since the bubble at the hilum in all grains appears to exert a repellent force upon the invasion of gelatinization. The lamellæ become slightly more distinct in more grains than in *Amaryllis belladonna,* but the definition is less clearly defined than in *Brunsvigia josephinæ.* A refractive border is formed as noted in both parents, but this border broadens more quickly around the entire grains and is more sharply differentiated from the less refractive area than in both parents. Gelatinization begins and proceeds in most of the grains as noted for both parents, with much the larger number following the method of *Amaryllis belladonna* than *Brunsvigia joseph-*

inæ. In addition to these methods two other forms of gelatinization not observed in the parental starches are very noticeable, namely, the widening of the border continues until the area immediately around the hilum is entirely inclosed, followed by considerable expansion with the later expulsion of the bubble and rapid gelatinization of this area and surrounding border; and in other grains the appearance of a number of irregular clefts over the entire grain, the grain rapidly swelling, followed by gelatinization, the area around the hilum of such grains proving the most resistant.

The gelatinized grains are swollen and much distorted, slightly more distorted in a larger number of grains than in *Amaryllis belladonna*, scarcely so much as in *Brunsvigia josephinæ*. In this reaction *Brunsdonna sanderæ alba* shows qualitatively a much closer relationship to *Amaryllis belladonna* than to *Brunsvigia josephinæ.*

The reaction with *chromic acid* begins in a few grains in half a minute. Complete gelatinization occurs in about 3 per cent of the grains in 5 minutes; and about 16 per cent of the grains and 80 per cent of the total starch in 15 minutes; in about 80 per cent of the grains and 97 per cent of the total starch in 20 minutes; and in all the grains and total starch in 25 minutes. (Chart D 2.)

The reaction with *pyrogallic* acid begins in rare grains in 1 minute. Complete gelatinization occurs in less than 1 per cent of the grains and about 1 per cent of the total starch in 5 minutes; and in less than 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; and in about 2 per cent of the grains and 10 per cent of the total starch in 30 minutes; and in about 5 per cent of the grains and 12 per cent of the total starch in 45 minutes; and in about 5 per cent of the grains and 12 per cent of the total starch in 60 minutes. (Chart D3.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 47 per cent of the grains and 73 per cent of the total starch in 1 minute; in about 75 per cent of the grains and 88 per cent of the total starch in 2 minutes; in about 85 per cent of the grains and 98 per cent of the total starch in 3 minutes; in about 95 per cent of the grains and over 99 per cent of the total starch in 5 minutes. A small amount at the distal end of a few grains persists at 10, 15, 30, and 45 minutes respectively. (Chart D 4.)

A small bubble appears sometimes at the hilum which expands very little and is very transient; this bubble is detected much less frequently and expands much less than in *A. belladonna;* probably about as frequently as in *Brunsvigia josephinæ.* The lamellæ become very sharply defined over the main body of the grain and a refractive border is quite prominent; the lamellæ are much more sharply defined and the border more prominent than in *A. belladonna;* the definition of the lamellæ is about the same, but the border not so prominent as in *Brunsvigia josephinæ.* Fissures are formed which proceed distalwards from the hilum and are usually slightly to considerably branched; these are very much more prominent and frequent than in *A. belladonna;* but they are much more delicate, less branched, and usually not similar in general character to *Brunsvigia josephinæ.* The lamellæ are disorganized with the appearance of quite refractive granules which are more frequently located near the distal margin, but a cluster of large granules may appear in the area around the hilum of a few grains, or be distributed through the main body of the grain. The granules appear much more frequently than in *A. belladonna:* they are not nearly so numerous, so large, nor so often located near the hilum or in the main body of the grain as in *Brunsvigia josephinæ.* The method of gelatinization much more closely follows that observed in *A. belladonna,* but evidence of inheritance from *Brunsvigia josephinæ* is occasionally present, even to a slightly greater degree than in *Brunsdonna sanderæ.*

The gelatinized grains are swollen and somewhat too much distorted; the distal refractive border in several grains being gelatinized previous to the area above in which a number of refractive granules resist gelatinization; the distortion is greater in more grains and the number of granules greater than in *A. belladonna,* but not nearly so much distortion nor so many granules as in *Brunsvigia josephinæ.* In this reaction *Brunsdonna sanderæ alba* shows qualitatively a much closer relationship to *A. belladonna* than to *Brunsvigia josephinæ.*

The reaction with *sulphuric acid* begins immediately and many are completely gelatinized in half a minute; gelatinization is complete in about 95 per cent of the grains and total starch in 1 minute, and in about 98 per cent of the grains and total starch in 1¼ minutes and all in 1½ minutes. (Chart D 5.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 50 per cent of the grains and total starch in 1 minute; in about 95 per cent of the grains and total starch in 2 minutes; in about 99 per cent of the grains and total starch in 3 minutes; rare small grains and the distal end of a few larger ones are ungelatinized in 5 minutes; gelatinization is completed in 10 minutes. (Chart D 6.)

The reaction with *potassium hydroxide* is complete in 30 seconds. (Chart D 7.)

The reaction with *potassium iodide* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the grains and 6 per cent of the total starch in 5 minutes; in about 12 per cent of the grains and 34 per cent of the total starch in 15 minutes; in about 15 per cent of the grains and 48 per cent of the total starch in 30 minutes; in about 26 per cent of the grains and 56 per cent of the total starch in 45 minutes; and in about 34 per cent of the grains and 64 per cent of the total starch in 60 minutes. (Chart D 8.)

The hilum swells very slowly, much less rapidly than in *A. belladonna,* about as in the unfissured hilum of *Brunsvigia josephinæ.* In a few grains a fissure at the hilum becomes enlarged and refractive more frequently than in *A. belladonna,* but much less frequently than in *Brunsvigia josephinæ.* The lamellæ over a larger part of the grain becomes more distinct and the definition is sharper than in *A. belladonna,* but not so sharp in so many grains as in *Brunsvigia josephinæ.* The lamellæ in the area for about one-third to one-half of the distance between the hilum and the distal margin often quickly lose their definition—this is the area in which the lamellæ are not usually clearly defined in *A. belladonna.* The fissures are more sharply defined, more branched, and delicate radiating fissures extend more frequently around the entire circumference of the hilum than in *A. bella-*

donna, although in most grains they much more closely resemble those of *A. belladonna* than of *Brunsvigia josephinæ.* The methods of gelatinization are more varied than in *A. belladonna,* though a much larger percentage shows a closer resemblance to *A. belladonna* than to *Brunsvigia josephinæ.* The lamellæ are disorganized with the appearance of more refractive granules than in *A. belladonna;* and when resistant they are located in the majority of grains as in *A. belladonna,* but in a small number they may be arranged and located variously as in *Brunsvigia josephinæ.*

The gelatinized grains are swollen and slightly distorted, more distortion especially at more varied points than in *A. belladonna,* but not in nearly so many grains as in *Brunsvigia josephinæ.* More granules are present and their location is more varied than in *A. belladonna,* but not so numerous as in *Brunsvigia josephinæ.* Many grains are found in which the reaction has proceeded little if any beyond the swelling of the hilum; a larger percentage than in both parents as well as in the other hybrid. In this reaction *Brunsdonna sanderæ alba* shows qualitatively a much closer relationship to *A. belladonna* than to *Brunsvigia josephinæ.*

The reaction with *potassium sulphocyanate* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 1 per cent of the grains and total starch in 5 and 15 minutes; and in less than 1 per cent of the grains and about 2 per cent of the total starch in 30 minutes; and over 2 per cent of the grains and 4 per cent of the total starch in 45 minutes; and no further gelatinization of the grains but about 5 per cent of the total starch in 60 minutes. (Chart D 9.)

The hilum swells very slowly in most of the grains, much more slowly than in *A. belladonna,* about the same as in grains of similar shape in *Brunsvigia josephinæ.* In a few grains either a thorn-shaped fissure or numerous radiating fissures quickly form at the hilar region, not commonly observed in *A. belladonna,* but the thorn-shape is quite characteristic of *Brunsvigia josephinæ.* There is an accentuation in the definition of the lamellæ and variation in refractivity of the different lamellæ of an individual grain. When the refractive border is present in the untreated grain, it is usually at the distal margin, as noted for both parents and the hybrid *Brunsdonna sanderæ,* the border being more common than in *A. belladonna* and in *Brunsdonna sanderæ,* but not nearly so frequent as in *Brunsvigia josephinæ.* Fissures of a similar character to those noted for both parents are observed, but their character and direction, though deeper, follow much more closely those described in *A. belladonna,* although fissures similar to those of *Brunsvigia josephinæ* are more frequently present than in *Brunsdonna sanderæ.* The lamellæ in the untreated grain are more sharply defined and vary more in refractivity in the individual grains than in *A. belladonna* and *Brunsdonna sanderæ,* but not so greatly in either as in *Brunsvigia josephinæ;* and during their disorganization they are more frequently deeply striated and break down into refractive granules than in *A. belladonna,* but the granules do not occur nearly so frequently as in *Brunsvigia josephinæ.* The most refractive lamellæ just above a homogeneously refractive distal border may be penetrated by deep short fissures and disorganized into refractive fragments of serrate appearance, which was not observed in *A. belladonna,* but was more common as well as more brilliant in *Brunsvigia josephinæ.*

The gelatinized grains are swollen and much distorted, the distortion being greater in more grains than in *A. belladonna* and *Brunsdonna sanderæ,* but not found in nearly so many as in *Brunsvigia josephinæ.* Refractive granules are not usually found in the grains at the end of 60 minutes, although more frequently than in *A. belladonna,* but not with nearly such frequency as in *Brunsvigia josephinæ.* The most resistant area is usually the same as noted in *A. belladonna,* but not commonly that observed in *Brunsvigia josephinæ.* The gelatinized grains often resemble the form of the untreated grain, but a little less frequently than in *A. belladonna,* but much more frequently than in *Brunsvigia josephinæ.*

In this reaction *Brunsdonna sanderæ alba* shows qualitatively a much closer relationship to *A. belladonna* than to *Brunsvigia josephinæ.*

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 11 per cent of the entire number of grains and 77 per cent of the total starch in 1 minute; in about 44 per cent of the grains and 88 per cent of the total starch in 3 minutes; in about 48 per cent of the grains and 91 per cent of the total starch in 5 minutes; in about 76 per cent of the grains and 96 per cent of the total starch in 15 minutes; in about 87 per cent of the grains and 99 per cent of the total starch in 30 minutes; in about 88 per cent of the grains and in more than 99 per cent of the total starch in 45 minutes; in about 91 per cent of the grains and in more than 99 per cent of the total starch in 60 minutes. (Chart D 10.)

The reaction with *sodium hydroxide* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 3 minutes; in about 3 per cent of the grains and 8 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 16 per cent of the total starch in 15 minutes; in about 25 per cent of the grains and 49 per cent of the total starch in 30 minutes; in about 30 per cent of the grains and 60 per cent of the total starch in 45 minutes; in about 33 per cent of the grains and 65 per cent of the total starch in 60 minutes. (Chart D 11.)

The reaction with *sodium sulphide* begins in a few grains in half a minute. Complete gelatinization occurs in about 1 per cent of the grains and 2 per cent of the total starch in 5 minutes; in over 1 per cent of the grains and about 3 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 5 per cent of the total starch in 30 minutes; in over 3 per cent of the grains and about 8 per cent of the total starch in 45 minutes; and in about 4 per cent of the grains and over 10 per cent of the total starch in 60 minutes. (Chart D 12.)

The reaction with *sodium salicylate* begins in half a minute. Complete gelatinization occurs in about 65 per cent of the grains and 71 per cent of the total starch in 5 minutes; in about 97 per cent of the grains and 99 per cent of the total starch in 10 minutes; and in over 99 per cent of the grains and total starch in 15 minutes. (Chart D 13.) A small bubble appears at the hilum which is a little more frequently inclosed within an enlarged fis-

sure than in *A. belladonna,* but very much less frequently than in *Brunsvigia josephinæ.* More than one bubble sometimes appears at the hilum, somewhat more frequently than in *A. belladonna,* but less frequently than in *Brunsvigia josephinæ.* The definition of the lamellæ, the appearance of the refractive border, the method of gelatinization, and the most resistant area in the grains are about the same in most of the grains as in *A. belladonna,* yet in some grains a resemblance to *Brunsvigia josephinæ* is quite marked, notably in the gelatinization of the entire border of some grains before progress is made in the main body of the grain, in the sharper definition of the lamellæ in a few grains, and in a greater distortion of the capsule in a few grains. The gelatinized grains are swollen and usually distorted more at the proximal than the distal end, they do not resemble the form of the untreated grain; slightly more distortion in some grains than in *A. belladonna,* but considerably less than in *Brunsvigia josephinæ.* In this reaction *Brunsdonna sanderæ alba* shows qualitatively a much closer relationship to *A. belladonna* than to *Brunsvigia josephinæ.*

The reaction with *calcium nitrate* begins in rare grains in half a minute. Complete gelatinization occurs in less than 0.5 per cent of the grains and over 4 per cent of the total starch in 5 minutes; and in over 4 per cent of the grains and about 22 per cent of the total starch in 15 minutes; in about 6 per cent of the grains and 30 per cent of the total starch in 30 minutes; in over 13 per cent of the grains and about 36 per cent of the total starch in 45 minutes; and in about 23 per cent of the grains and 41 per cent of the total starch in 60 minutes. (Chart D 14.)

The reaction with *uranium nitrate* begins in rare grains in half a minute. Complete gelatinization occurs in about 0.5 per cent of the grains and 2 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 7 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 15 per cent of the total starch in 30 minutes; in about 14 per cent of the grains and 30 per cent of the total starch in 45 minutes; and in about 21 per cent of the grains and 50 per cent of the total starch in 60 minutes. (Chart D 15.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 23 per cent of the grains and 72 per cent of the total starch in 5 minutes; in about 87 per cent of the grains and 97 per cent of the total starch in 15 minutes; and in about 97 per cent of the grains and over 99 per cent of the total starch in 30 minutes. (Chart D 16.)

The reaction with *cobalt nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; slight progress in 15 minutes; still less than 0.5 per cent complete of the entire number of grains, and 3 per cent of the total starch in 30 minutes; about the same in 45 and 60 minutes, respectively. (Chart D 17.) A group of irregularly arranged fissures may form in the region of the hilum, and these may extend through the grain, still retaining their irregularity. This may be followed by gelatinization starting at the proximal end and proceeding distalwards, the most resistant area being located near and at the distal margin. In the few grains which showed any progress with this reagent the relationship appeared closer to *A. belladonna* than to *Brunsvigia josephinæ.*

The reaction with *copper nitrate* begins in rare grains in half a minute. Complete gelatinization occurs in but rare grains, less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 2.5 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 6 per cent of the total starch in 30 minutes; in about 2 per cent of the grains and 10 per cent of the total starch in 45 minutes; in about 3 per cent of the grains and 18 per cent of the total starch in 60 minutes. (Chart D 18.) Gelatinization in most of the grains proceeds from the proximal end to the distal margin as noted in *A. belladonna;* but in a few grains deep fissures are formed, along the course of which the process proceeds as noted more commonly in *Brunsvigia josephinæ,* although even in these grains the most resistant area is more frequently located at the proximal end. In the few grains affected by the reagent, these reactions exhibit a closer relationship to *A. belladonna* than to *Brunsvigia josephinæ.*

The reaction with *cupric chloride* begins in rare grains in 1 minute. Complete gelatinization was observed in less than 0.5 per cent of the entire number of grains and the total starch in 5 minutes; in about 0.5 per cent of the grains and 2.5 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 6 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 7.5 per cent of the total starch in 45 minutes; in about 2 per cent of the grains and 10 per cent of the total starch in 60 minutes. (Chart D 19.) Irregular fissures appear in the area around the hilum and in some grains also at the distal margin. The process then generally proceeds from the proximal end and gradually advances towards the distal margin. The progress of the reaction more closely follows that of *A. belladonna* than of *Brunsvigia josephinæ,* but the appearance of fissures is more frequent than in these species. In the few grains affected by the reagent, the relationship appears closer to *A. belladonna* than to *Brunsvigia josephinæ.*

The reaction with *barium chloride* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the grains and total starch in 5 minutes; and in about 0.5 per cent of the grains and total starch in 15, 30, 45, and 60 minutes, respectively. (Chart D 20.)

The reaction with *mercuric chloride* begins in very rare grains in 1 minute. Complete gelatinization occurs only in rare grains and the process has begun in very few grains, less than 0.5 per cent of both the entire number of grains and of the total starch in 5 minutes; very little progress is observed in 15 minutes; still less than 0.5 per cent of the entire number of grains and about 0.5 per cent of the total starch in 30 minutes; about the same in 45 and 60 minutes, respectively. (Chart D 21.)

BRUNSDONNA SANDERÆ (HYBRID).

HISTOLOGIC PROPERTIES.

(Plate 1, fig. 6; Charts D 1 to D 21.)

The *form* of the grains is usually simple and isolated with the exception of a few which occur in aggregates

of 2, 3, or 4 components, in this resembling *Brunsvigia josephinæ* and *Brunsdonna sanderæ alba.* A few compound grains are observed, some consisting of two small grains, each with its own lamellæ clearly defined, both inclosed in secondary lamellæ, and so located that they are at the proximal end of a very broad ovoid grain; and others consist of two small grains inclosed in a very few secondary lamellæ. The compound grains noted in this starch are more like those of *A. belladonna* than those of *Brunsvigia josephinæ.* The grains are often regular, but sometimes rather more irregular in form than those of *A. belladonna* but much less than those of *Brunsvigia josephinæ,* and the irregularities are due to the following causes: (1) rounded projections from the sides and proximal and distal ends; (2) deviation of the longitudinal axis of the grain usually near the distal end; (3) notches in the margin of varying size and position. The conspicuous forms are elongated elliptical, with or without a flattened distal end, ovoid (pure and elongated), and nearly round. There are also triangular and pyriform grains. The grains are not flattened. In form *Brunsdonna sanderæ* much more closely resembles *A. belladonna* than *Brunsvigia josephinæ.* It shows resemblance to *Brunsvigia josephinæ* chiefly in the irregularity and variety of its form. The grains are not so near *A. belladonna* in form as those of *Brunsdonna sanderæ alba,* and not so near *Brunsvigia josephinæ* in the number and type of compound grain as those of *Brunsdonna sanderæ alba.*

The *hilum* is not so distinct as in either parent, but is nearer *A. belladonna* in this respect and the same as in *Brunsdonna sanderæ alba.* It is a small round spot, which is often not fissured but more apt to be fissured than in either of the parents, which are alike. In this respect it differs from *Brunsdonna sanderæ alba* which is more often fissured than the parents. It is eccentric from 0.36 to 0.14, usually 0.25 of the longitudinal axis. *Brunsdonna sanderæ* is nearer to *A. belladonna* than to *Brunsvigia josephinæ* in the character and eccentricity of the hilum and is somewhat closer to the parents than is *Brunsdonna sanderæ alba.*

The *lamellæ* are rather fine and usually not very distinct, and as a rule are like those noted under *A. belladonna,* although, in some grains they are irregular and have a variety of forms as noted under *Brunsvigia josephinæ.* The number counted on the larger grains varies from 20 to 45, usually 34. In character and arrangement of lamellæ *Brunsdonna sanderæ* is closer to *A. belladonna* than to *Brunsvigia josephinæ,* but in number slightly closer to the latter. In the character and arrangement of the lamellæ *Brunsdonna sanderæ* and *Brunsdonna sanderæ alba* resemble one another closely, except that the average number on these grains is not so near the number on *Brunsvigia josephinæ* as is that on the grains of *Brunsdonna sanderæ alba.*

The grains vary in *size* from the smaller which are 10 by 8μ, to the larger, narrower forms which are 60 by 36μ, and the larger, broader forms which are 70 by 54μ in length and breadth. The common forms are 30 by 22μ and 34 by 30μ in length and breadth. *Brunsdonna sanderæ* is nearer to *A. belladonna* in ratio of length to width of the grain, and in larger grains in length, are nearer *A. belladonna;* but in length of the common-sized grains they are nearer *Brunsvigia josephinæ.* *Brunsdonna sanderæ* is not so near *A. belladonna* in size as is *Brunsdonna sanderæ alba.*

Polariscopic Properties.

The *figure* varies from centric to very eccentric, with many more of the latter so that the mean is quite eccentric, although somewhat less than in *A. belladonna* and considerably more than in *Brunsvigia josephinæ.* The figure is generally distinct and clean-cut, not always so distinct as in *A. belladonna,* but much more so than in *Brunsvigia josephinæ.* The lines are generally fine with slight broadening towards the margin, the mean not quite so fine as in *A. belladonna,* but decidedly finer than in *Brunsvigia josephinæ.* The lines are more frequently straight and intersect obliquely, although they are more frequently bent and bisected and there is greater variation in the angle of their intersection than in *A. belladonna,* but in many more figures the lines are straight and intersect more obliquely than in *Brunsvigia josephinæ.* Compound figures are more numerous than in *A. belladonna* but considerably less frequent than in *Brunsvigia josephinæ.*

The *degree of polarization* is very high (value 95), slightly less than in *A. belladonna* but decidedly more than in *Brunsvigia josephinæ.* Greater variation occurs among the individual grains as well as in the same aspect of a given grain than in *A. belladonna,* but decidedly less than in *Brunsvigia josephinæ.*

With *selenite* the quadrants are generally sharply defined, but there is greater variation with the mean not quite so sharp as in *A. belladonna,* but decidedly more sharp than in *Brunsvigia josephinæ.* The mean shape is somewhat less regular than in *A. belladonna,* but decidedly more regular than in *Brunsvigia josephinæ.* The colors are generally pure, although impurity is found (due both to a low degree of polarization and the greenish tinge due to a high degree of polarization) more frequently than in *A. belladonna,* but the colors are more frequently pure than in *Brunsvigia josephinæ.*

In the degree of polarization, character of the figure, and appearance with selenite *Brunsdonna sanderæ* is closer to *A. belladonna* than to *Brunsvigia josephinæ;* but not quite so close to *A. belladonna* as is *Brunsdonna sanderæ alba.*

Iodine Reactions.

With 0.25 per cent Lugol's solution most of the grains at once color a moderate blue-violet with a few moderately deep (value 55), about the same tint and depth as in *A. belladonnæ* but lighter and a little redder than in *Brunsvigia josephinæ;* the color deepens rapidly, becoming slightly deeper and a little more bluish than in *A. belladonna* and *Brunsdonna sanderæ alba,* but neither quite so bluish nor so deep as in *Brunsvigia josephinæ.* With an 0.125 Lugol's solution the grains color a very light blue-violet, about the same as in *A. belladonna* and *Brunsdonna sanderæ alba* but a little lighter than in *Brunsvigia josephinæ;* the color deepens, becoming darker than in either parent as well as in *Brunsdonna sanderæ alba.* After heating in water until the grains are gelatinized and then adding a 2 per cent Lugol's solution the *grains* color a moderate to very deep indigo blue, rarely with reddish tint, much nearer the tint of *A. belladonna* though not so deep and somewhat less reddish.

The *solution* becomes a deep indigo-blue, slightly deeper but of about the same purity as in *A. belladonna,* but not quite so deep and less impure in tint than in *Brunsvigia josephinæ.* The gelatinized grains color more deeply and are not quite so pure in tint, while the *solution* is slightly deeper than in *Brunsdonna sanderæ alba.* If the preparation is boiled for 2 minutes and then treated with a 2 per cent Lugol's solution the *grain-residues* color a deep blue, a few with reddish tint, deeper than in both parents and less varied in tint than in *Brunsvigia josephinæ;* also deeper but nearer the tint of *Brunsdonna sanderæ alba.* Most of the *capsules* color a light amethyst to very deep heliotrope with a few reddish purple, the mean is deeper and less reddish than in both parents, and very much deeper but slightly more reddish than in *Brunsdonna sanderæ alba.* Quantitatively and qualitatively the iodine reactions show a closer relationship to *A. belladonna* than to *Brunsvigia josephinæ.* The resemblances, on the whole, are not quite so close to *A. belladonna* as those of *Brunsdonna sanderæ alba.*

Aniline Reactions.

With *gentian violet* the grains stain moderately light at once, a little deeper than in *Brunsdonna sanderæ alba,* and deeper than in both parents; and in half an hour they become moderately deep with scattered very deeply colored grains (value 63); deeper than in both parents, but nearer to *Brunsvigia josephinæ;* and deeper but nearer to *Brunsdonna sanderæ alba* than to the parents.

With *safranin* the grains stain lightly with a few deep at once, deeper than in both parents as well as in *Brunsdonna sanderæ alba;* in half an hour the grains become moderate to very deep, the mean moderately deep to deep (value 68), decidedly deeper than in both parents, though a little nearer to *A. belladonna,* and a little deeper than *Brunsdonna sanderæ alba.*

In the reaction with gentian violet *Brunsdonna sanderæ* is closer to *Brunsvigia josephinæ* than to *A. belladonna.* In the reaction with safranin it is closer to *A. belladonna* than to *Brunsvigia josephinæ.*

The reactions with aniline stains are deeper in *Brunsdonna sanderæ* than in *Brunsdonna sanderæ alba* and are not so close to the parents as are those of *Brunsdonna sanderæ alba.*

Temperature Reactions.

The majority of the grains are gelatinized at 70° to 71.5° C., and in all but the distal end of rare grains at 72° to 72.5° C., mean 72.2° C. The temperature of gelatinization of *Brunsdonna sanderæ* is much closer to *A. belladonna* than to *Brunsvigia josephinæ.* The temperatures of gelatinization of the two hybrids are identical.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in a few grains immediately. Complete gelatinization occurs in about 8 per cent of the entire number of grains and 15 per cent of the total starch in 5 minutes; in about 72 per cent of the grains and 85 per cent of the total starch in 15 minutes; in about 95 per cent of the grains and 98 per cent of the total starch in 30 minutes; in about 97 per cent of the grains and 99 per cent of the total starch in 45 minutes; in about 99 per cent of the grains and over 99 per cent of the total starch in 60 minutes. (Chart D 1.) A bubble appears at the hilum in most of the grains which more closely resembles the condition observed in *A. belladonna* than in *Brunsvigia josephinæ,* although in a small number of grains the expansion of the bubble and the enlargement of a fissure at the hilum less closely resembles *A. belladonna* than *Brunsvigia josephinæ.* The bubble, as a rule, is more transient than in both parents, about the same as in *Brunsdonna sanderæ alba.* The lamellæ become slightly more distinct in a few more grains than in *A. belladonna,* but not as distinct as in *Brunsvigia josephinæ,* nor in so many grains as in *Brunsdonna sanderæ alba.* A refractive border is formed, similar to that noted in both parents, but the border is more prominent and becomes wider previous to gelatinization. The refractivity of this border is not so great in so many grains as in *Brunsdonna sanderæ alba.* Gelatinization begins and proceeds in most of the grains as noted for both parents, much the larger number following the methods observed in *A. belladonna* than in *Brunsvigia josephinæ;* even more like the former than was found in *Brunsdonna sanderæ alba.* In addition to the methods observed in the parents, those described for *Brunsdonna sanderæ alba* are noted. The gelatinized grains are swollen and distorted, slightly more distorted than in *A. belladonna,* but the distortion is not so great in so many grains as in *Brunsvigia josephinæ* and about the same as in *Brunsdonna sanderæ alba.* In this reaction *Brunsdonna sanderæ* shows qualitatively a closer relationship to *A. belladonna* than to *Brunsdonna sanderæ alba* and a much closer relationship to *A. belladonna* than to *Brunsvigia josephinæ,* although in a few grains the relationship to the latter is quite marked.

In the reaction with *chromic acid* gelatinization is complete in a few rare grains and about 1 per cent of the total starch in 5 minutes; in rare grains and in about 20 per cent of the total starch in 10 minutes; in about 50 per cent of the grains and 80 per cent of the total starch in 15 minutes; in about 50 per cent of the grains and 92 per cent of the total starch in 25 minutes; in about 99 per cent of the grains and 99 per cent of the total starch in 30 minutes, and in all in 35 minutes. (Chart D 2.)

The reaction with *pyrogallic acid* begins in rare grains in 1 minute and gelatinization is complete in less than 0.5 per cent of the grains and in less than 1 per cent of the total starch in 5 minutes; in less than 1 per cent of the grains and over 1 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 4 per cent of the total starch in 30 minutes; in about 3 per cent of the grains and 7 per cent of the total starch in 45 and 60 minutes. (Chart D 3.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in rare grains and in about 35 per cent of the total starch in 1 minute; and in about 30 per cent of the grains and 65 per cent of the total starch in 2 minutes; in about 78 per cent of the grains and 92 per cent of the total starch in 3 minutes; in about 90 per cent of the grains and 98 per cent of the total starch in 5 minutes; and more than 99 per cent of the grains and total starch in 10, 15, 30, and 45 minutes, and in all in 60 minutes. (Chart D 4.)

A small bubble appears at the hilum which expands little if any in most of the grains and is very transient; is more transient and expands less in fewer grains than in *A. belladonna;* but is more prominent than in *Brunsvigia josephinæ* as well as in *Brunsdonna sanderæ alba.* The lamellæ become more distinct over the body of the grain, much more sharply defined than in *A. belladonna,* not quite so sharp as in *Brunsvigia josephinæ* as well as in *Brunsdonna sanderæ alba.* A refractive border is formed which is more prominent and broader than in *A. belladonna,* but not nearly so broad as in *Brunsvigia josephinæ,* nor quite so broad as in *Brunsdonna sanderæ alba.* Two well-defined but delicate fissures usually proceed distalward from the hilum, and may extend but a short distance and be unbranched or advance almost to the distal margin and become sparingly branched; these fissures are very much more commonly present than in *A. belladonna,* but are much more delicate and much less branched and less varied in character than in *Brunsvigia josephinæ.* They are similar in character but less branched than in *Brunsdonna sanderæ alba.* The mesial region is disorganized with the appearance of quite refractive granules with more frequency than in *A. belladonna,* but the granules are not nearly so refractive nor so numerous in a given grain, nor are they present in nearly so many grains as in *Brunsvigia josephinæ;* and these granules appear less frequently than in *Brunsdonna sanderæ alba.* In most of the grains the process much more closely follows that noted in *A. belladonna* and *Brunsdonna sanderæ alba* than in *Brunsvigia josephinæ;* in a few grains, however, the distal margin is gelatinized with considerable distortion, previous to the gelatinization of a number of refractive granules in the main body of the grain; these granules are usually more resistant and more numerous in an area just above the distorted distal margin. The gelatinized grains are swollen and slightly to considerably distorted, a few grains with refractive granules, as noted above; a few more grains are distorted and contain refractive granules than in *A. belladonna;* but neither so much distortion nor nearly so many grains with refractive granules as in *Brunsvigia josephinæ.*

In this reaction *Brunsdonna sanderæ,* excepting in a few grains, shows qualitatively a much closer relationship to *A. belladonna* than to *Brunsvigia josephinæ;* the relationship is very close to *Brunsdonna sanderæ alba,* but is closer to *A. belladonna* than this hybrid.

The reaction with *sulphuric acid* begins immediately; many grains are gelatinized in half a minute. Complete gelatinization occurs in about 90 per cent of the grains and 95 per cent of the total starch in 1 minute; and in over 99 per cent of the grains and total starch in 1.5 minutes; gelatinization is entirely completed in 2 minutes. (Chart D 5.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 30 per cent of the grains and total starch in 1 minute; in about 90 per cent of the grains and total starch in 2 minutes; in about 97 per cent of the grains and total starch in 3 minutes; and over 99 per cent of the grains and total starch in 4, 5, and 10 minutes. (Chart D 6.) The small portion of a few grains at the distal end still remains ungelatinized until the end of the reaction.

The reaction with *potassium hydroxide* is complete in all the grains in 25 seconds. (Chart D 7.)

The reaction with *potassium iodide* begins in a few grains immediately, and gelatinization is complete in about 5 per cent of the grains and 16 per cent of the total starch in 5 minutes; in about 24 per cent of the grains and 48 per cent of the total starch in 15 minutes; in about 33 per cent of the grains and 57 per cent of the total starch in 30 minutes; in about 40 per cent of the grains and 65 per cent of the total starch in 45 minutes; and in about 46 per cent of the grains and 72 per cent of the total starch in 60 minutes. (Chart D 8.)

The hilum swells, no bubble was detected at this region; occasionally fissures are present which become enlarged and more refractive; the hilum swells less rapidly, and fissures are somewhat more frequent than in *A. belladonna,* the hilum swells more rapidly and the fissures are much less frequent than in *Brunsvigia josephinæ,* and are a little less prominent than in *Brunsdonna sanderæ alba.* The lamellæ immediately become more distinct over the entire grain with the exception of an occasional narrow, refractive border in which the lamellæ may gradually become sharply defined; the definition of the lamellæ for about one-third to one-half of the distance between the hilum and the distal margin is soon lost; this being the area in which the lamellæ are not usually distinct in *A. belladonna.* The lamellæ become more distinct over a larger area of the grain than in *A. belladonna,* though the definition more closely resembles this species in most of the grains than in *Brunsvigia josephinæ,* about the same as in *Brunsdonna sanderæ alba.* The fissures are a little more clearly defined and more frequently branched than in *A. belladonna,* though not nearly so prominent nor so varied as in *Brunsvigia josephinæ;* not quite so deep nor so varied as in *Brunsdonna sanderæ alba.* The reaction usually follows the same course as in *A. belladonna,* though a few grains may exhibit some characteristics noted in *Brunsvigia josephinæ.* The lamellæ are disorganized with the appearance of more refractive granules than in *A. belladonna,* but not nearly so many as in *Brunsvigia josephinæ.* The refractive granules are generally located at or near the distal margin, as in *A. belladonna,* although more often at other points than in this species; much more frequently at this margin than in *Brunsvigia josephinæ;* not quite so often so located as in *Brunsvigia josephinæ* as those of *Brunsdonna sanderæ alba.*

The gelatinized grains are swollen and very little to considerably distorted, a little more distortion than in *A. belladonna,* but not nearly so much as in *Brunsvigia josephinæ;* nor in quite so many grains as in *Brunsdonna sanderæ alba.* There is a larger proportion of grains in which the reaction has made little if any progress beyond the swelling of the hilum than in both parents, but in not quite so many as in *Brunsdonna sanderæ alba.*

In the reaction with potassium iodide *Brunsdonna sanderæ* shows qualitatively a much closer relationship to *A. belladonna* than to *Brunsvigia josephinæ.* The relationship appears closer to *A. belladonna* than that of *Brunsdonna sanderæ alba.*

The reaction with *potassium sulphocyanate* begins in a few grains in 1 minute. Gelatinization is complete in less than 1 per cent of the grains and in about 1 per cent of the total starch in 5 minutes; in about 2 per cent

of the grains and 5 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 8 per cent of the total starch in 30 minutes; in about 7 per cent of the grains and 12 per cent of the total starch in 45 minutes; and in about 10 per cent of the grains and 15 per cent of the total starch in 60 minutes. (Chart D 9.)

In the majority of grains the hilum swells much more slowly than in *A. belladonna,* but not quite so slowly as in the grains of similar shape, very much slower than most of the grains of *Brunsvigia josephinæ,* and a little less slowly than in *Brunsdonna sanderæ alba.* In a few grains an enlarged fissure appears at the hilum, such a cleft not being commonly observed in *A. belladonna,* but present in most grains of *Brunsvigia josephinæ,* and a little more frequently in *Brunsdonna sanderæ alba,* than in *Brunsdonna sanderæ.* The definition of the lamellæ becomes a little sharper; a refractive border is a little more prominent than in *A. belladonna,* but not nearly so frequent as in *Brunsvigia josephinæ;* a little less often observed than in *Brunsdonna sanderæ alba.* In most of the grains fissures of a character similar (though deeper) to those of *A. belladonna* are observed; but in a few grains the fissures are similar to those more commonly observed in *Brunsvigia josephinæ;* the fissures somewhat more closely follow those of *A. belladonna* than in *Brunsdonna sanderæ alba.* The disorganization of the lamellæ is a little more frequently accompanied by the appearance of refractive granules which are a little more varied in location than in *A. belladonna,* but with not nearly the frequency nor nearly so many located as commonly noted in *Brunsvigia josephinæ;* they are a little less frequently located as in *Brunsvigia josephinæ* than in *Brunsdonna sanderæ alba.*

The gelatinized grains are swollen and slightly to considerably distorted; the distortion is a little greater in more grains than in *A. belladonna* but in not nearly so many grains as in *Brunsvigia josephinæ;* nor in quite so many as in *Brunsdonna sanderæ alba.* At the end of the reaction (60 minutes) granules are not generally present in these gelatinized grains as observed in *A. belladonna;* but in a few grains a similar arrangement to that noted for *Brunsvigia josephinæ* is noted; these granules do not remain in quite so many grains as in *Brunsdonna sanderæ.* The gelatinized grains bear a little less resemblance to the untreated grain than those of *A. belladonna,* but much closer than those of *Brunsvigia josephinæ;* and a little closer resemblance than those of *Brunsdonna sanderæ alba.*

In this reaction *Brunsdonna sanderæ* shows qualitatively a much closer relationship to *A. belladonna* than to *Brunsdonna josephinæ.* The relationship is a little closer to *A. belladonna* than that of *Brunsdonna sanderæ alba.*

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 52 per cent of the entire number of grains and 90 per cent of the total starch in 1 minute; in about 63 per cent of the grains and 95 per cent of the total starch in 3 minutes; in about 75 per cent of the grains and 97 per cent of the total starch in 5 minutes; in about 81 per cent of the grains and 99 per cent of the total starch in 15 minutes; in about 91 per cent of the grains and in more than 99 per cent of the total starch in 30 minutes; in about 93 per cent of the grains and more than 99 per cent of the total starch in 45 minutes; in about 96 per cent of the grains and in more than 99 per cent of the total starch in 60 minutes. (Chart D 10.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 10 per cent of the total starch in 3 minutes; in about 10 per cent of the grains and 30 per cent of the total starch in 5 minutes; in about 37 per cent of the grains and 65 per cent of the total starch in 15 minutes; in about 50 per cent of the grains and 75 per cent of the total starch in 30 minutes; in about 53 per cent of the grains and 83 per cent of the total starch in 45 minutes; in about 55 per cent of the grains and 88 per cent of the total starch in 60 minutes. (Chart D 11.)

The reaction with *sodium sulphide* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the grains and 5 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 25 per cent of the total starch in 15 minutes; in about 12 per cent of the grains and 30 per cent of the total starch in 30 minutes; and in about 14 per cent of the grains and 40 per cent of the total starch in 45 and 60 minutes. (Chart D 12.)

The reaction with *sodium salicylate* begins in half a minute. Gelatinization is complete in over 77 per cent of the grains and 84 per cent of the total starch in 5 minutes; and over 99 per cent of the grains and total starch in 10 minutes; and in all in 15 minutes. (Chart D 13.) A small bubble appears at the hilum which is a little more frequently inclosed within an enlarged fissure than in *A. belladonna,* but very much less frequently than in *Brunsvigia josephinæ;* and slightly less often than in *Brunsdonna sanderæ alba.* The definition of the lamellæ, the appearance of the refractive border, the methods of gelatinization, and the resistant area of starch in the grain are about the same in most of the grains as noted for *A. belladonna;* yet in a few grains all of these features more closely follow those observed in *Brunsvigia josephinæ;* the resemblance is a little closer in these points to *A. belladonna* than in *Brunsdonna sanderæ alba.* The gelatinized grains are swollen and usually more distorted at the proximal than the distal margin, as noted for the parents and *Brunsdonna sanderæ alba.* Slightly more distortion is found in a few grains than in *A. belladonna,* but in not nearly so many grains as in *Brunsvigia josephinæ,* and in a slightly less number than in *Brunsdonna sanderæ alba.* They do not resemble those of the parents, as was noted also in *Brunsdonna sanderæ alba.* In this reaction *Brunsdonna sanderæ* shows qualitatively a much closer relationship to *A. belladonna* than to *Brunsvigia josephinæ,* and resemblance to *A. belladonna* is a little closer than that of *Brunsdonna sanderæ alba.*

The reaction with *calcium nitrate* begins in a few grains immediately. Gelatinization is complete in about 1 per cent of the grains, and 5 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 39 per cent of the total starch in 15 minutes; in over 17 per cent of the grains and 50 per cent of the total starch in 30 minutes; in about 24 per cent of the grains and 63 per cent of the total starch in 45 minutes; and in about

34 per cent of the grains and 68 per cent of the total starch in 60 minutes. (Chart D 14.)

The reaction with *uranium nitrate* begins in a few grains in half a minute. Complete gelatinization occurs in about 0.5 per cent of the grains and 5 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 20 per cent of the total starch in 15 minutes; in about 24 per cent of the grains and 52 per cent of the total starch in 30 minutes; in about 24 per cent of the grains and 60 per cent of the total starch in 45 minutes; in about 28 per cent of the grains and 70 per cent of the total starch in 60 minutes. (Chart D 15.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 40 per cent of the grains and 85 per cent of the total starch in 5 minutes; in about 90 per cent of the grains and over 99 per cent of the total starch in 15 minutes; and in over 98 per cent of the grains and over 99 per cent of the total starch in 30 minutes. (Chart D 16.)

The reaction with *cobalt nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; slight progress in 15 minutes; in about 2 per cent of the grains and 5 per cent of the total starch in 30 minutes; in about 4 per cent of the grains and 9 per cent of the total starch in 45 minutes; in about 7 per cent of the grains and 12 per cent of the total starch in 60 minutes. (Chart D 17.) Fissures appear at the region of the hilum with an irregular arrangement and may extend over the grain, gelatinization later beginning at the proximal end and proceeding distalward. The process much more closely follows that of *A. belladonna* than of *Brunsvigia josephinæ,* the fissures are not quite so deep and the reaction less rapid, though otherwise about the same as in *Brunsdonna sanderæ alba,* the relationship being much closer between the hybrids than to either parent.

The reaction with *copper nitrate* begins in a few grains in half a minute. Complete gelatinization occurs rarely in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes. Complete gelatinization occurs in about 10 per cent of the entire number of grains and 18 per cent of the total starch in 15 minutes; in about 14 per cent of the entire number of grains and 21 per cent of the total starch in 30 minutes; in about 18 per cent of the grains and 25 per cent of the total starch in 45 minutes; about the same in 60 minutes. (Chart D 18.) Gelatinization in most of the grains proceeds from the proximal end as in *A. belladonna,* but in a few grains the process advances through the mesial portion along the courses of fissures as is more frequently observed in *Brunsvigia josephinæ,* though ultimately the proximal end is usually gelatinized before the distal end more frequently than in *Brunsvigia josephinæ;* the fissures are a little less deep and fewer grains follow the method commonly observed in *Brunsvigia josephinæ* than in *Brunsdonna sanderæ alba.* The reactions indicate a much closer relationship to *A. belladonna* than to *Brunsvigia josephinæ;* a little less close to *Brunsvigia josephinæ* than is observed in *Brunsdonna sanderæ alba;* but the relationship is much closer to the other hybrid than to either parent.

The reaction with *cupric chloride* begins in a few grains in half a minute. Complete gelatinization occurs in a few grains, but less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 4 per cent of the total starch in 15 minutes; in about 2.5 per cent of the grains and 7 per cent of the total starch in 30 minutes; in about 5 per cent of the grains and 9 per cent of the total starch in 45 minutes; in about 6 per cent of the grains and 12 per cent of the total starch in 60 minutes. (Chart D 19.) Irregular fissures form at the region of the hilum and also around the distal margin of some grains; gelatinization then starts at the proximal end and proceeds more rapidly from that end; the distal end being very resistant; the appearance of fissures is more frequent but the general course of the reaction is the same in most grains affected as in *A. belladonna,* less varied than in *Brunsvigia josephinæ,* about the same as in *Brunsdonna sanderæ alba.* The reaction indicates a closer relationship to *A. belladonna* than to *Brunsvigia josephinæ,* and a much closer resemblance to *Brunsdonna sanderæ alba* than to either parent.

The reaction with *barium chloride* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the grains and total starch in 5 minutes; and in less than 0.5 per cent of the grains and about 0.5 per cent of the total starch in 15, 30, 45, and 60 minutes. (Chart D 20.)

The reaction with *mercuric chloride* begins in rare grains in 1 minute. Complete gelatinization occurs in 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; very little if any progress is observed in 15, 30, 45, and 60 minutes, respectively. (Chart D 21.)

2. HIPPEASTRUM.

This genus includes about 40 species of bulbous plants that are natives of tropical America. They are commonly cultivated under the name *Amaryllis.* Hybridization has been carried on quite largely.

Starches of three sets of parent-stocks and hybrid-stocks were studied, all of the specimens being closely related garden forms raised by Veitch & Sons, London, England.

3. Starches of *Hippeastrum titan, H. cleonia,* and *H. titan-cleonia.*
4. Starches of *H. ossultan, H. pyrrha,* and *H. ossultan-pyrrha.*
5. Starches of *H. dæones, H. zephyr,* and *H. dæones-zephyr.*

2. Starches of Hippeastrum titan, H. cleonia, and H. titan-cleonia.

Hippeastrum titan (Seed Parent).

(Plate 2, fig. 7; Charts D 22 to D 42.)

Histologic Properties.

In *form* the grains are usually simple and isolated, but a fair number of compound grains are observed, usually consisting of 2 components, but occasionally having three or more. There are also a few aggregates, which are usually doublets of the same size, or of very unequal size, but triplets and quadruplets linearly

arranged may be seen. The grains tend to be regular in form though rarely is a perfectly regular form seen, the rest having very numerous slight irregularities. These irregularities are due to the following causes: (1) Small nipple-like and larger pointed protuberances from either end and occasionally from the sides; (2) shallow depressions in and flattening of the margin, probably not in the nature of pressure facets; (3) a greater development of one part of the distal end or of one side. The conspicuous forms are ovoid, elongated or broad, pointed at one end or blunt at both ends, elliptical and nearly round. There are also plano-convex, dome-shaped, round, triangular, irregularly quadrilateral with rounded corners, reniform, finger-shaped, and lenticular forms.

The *hilum,* when not fissured, is not very distinct and appears of a round or elongated lenticular shape. In the latter case it is situated in the longitudinal axis of the grain. The hilum is often fissured, and the fissures take the following forms: (1) A single fissure which is not long but which is deep and usually not straight but angled, from which single fissure other small fissures sometimes branch out; (2) an irregularly cruciform or Y-shaped fissure; (3) a small, straight horizontal or oblique fissure. When more than one hila occur they are usually separated by small straight fissures, or they may be connected by a straight fissure between the two. The hilum is often centric, but is more frequently eccentric, the range of eccentricity being from 0.45 to 0.29, commonly 0.35.

The *lamellæ* are often indistinct, but when they can be seen they appear as rather coarse bands which are always continuous near the hilum and sometimes throughout the rest of the grain, but in other cases they become discontinuous. Near the hilum they are round, oval, or have the form of the outline of the grain; throughout the rest of the grains they have in general the form of the contour, in some cases, however, considerably modified. The number counted on some of the common size and larger grains varied from 8 to 12.

The *size* of the grains varies from the smaller, which are 5 by 5μ, to the larger elongated forms, which are 40 by 30μ, and the larger broad forms, which are 40 by 36μ or even, rarely, 24 by 40μ in length and breadth. The common sizes are 23 by 14μ, 24 by 20μ, and 20 by 24μ.

Polariscopic Properties.

The *figure* is centric to very eccentric, the mean is nearly centric; it is usually distinct and clean-cut. The lines vary from fine to moderately coarse and usually intersect obliquely, but they may be so arranged as to form a median line with bisected ends or intersect at right angles. In the greater number of grains the lines are straight with broadening at the margin, yet they are sometimes either bent or bisected. Double and multiple figures are moderately frequent.

The *degree of polarization* is high to very high (value 83). The range of polarization in the individual grains is from moderately high to very high, but not many of the former, and there is also frequent variation in the same aspect of a given grain.

With *selenite* the quadrants are generally well defined, usually unequal in size, and regular in the majority of grains, yet irregularity is moderately frequent. The colors are usually pure.

Iodine Reactions.

With 0.25 Lugol's solution the grains immediately color a moderate blue-violet (value 52), and the color deepens quickly, becoming bluer in tint. With 0.125 per cent Lugol's solution the grains become light to moderate blue-violet, and the color deepens quickly to moderately deep. After heating in water until the grains are gelatinized and then adding a 2 per cent Lugol's solution the gelatinized *grains* color very light to deep blue, a few with reddish tint, since a majority of grains are light; the mean is moderately light. The *solution* colors a deep indigo-blue. If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* color from light to deep blue, frequently tinged with red; most of the grain-residues are moderate in depth, and most of the *capsules* color a light to deep heliotrope, a few old rose, the mean being moderate in depth. The starch *solution* colors a very deep indigo-blue.

Aniline Reactions.

With *gentian violet* the grains stain very lightly at once, and in half an hour become moderately light to moderate in depth (value 45).

With *safranin* the grains color very light at once, and in half an hour become moderate in depth (value 50).

Temperature Reactions.

The majority of the grains are gelatinized at 74° to 75° C., and of all but rare grains at 77° to 77.5° C., mean 77.25° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 17 per cent of the grains and 21 per cent of the total starch in 15 minutes; in about 27 per cent of the grains and 31 per cent of the total starch in 30 minutes; in about 31 per cent of the grains and 34 per cent of the total starch in 45 minutes; little further change—about 36 per cent of the total starch in 60 minutes. (Chart D 22.) One or more small bubbles, more frequently the former, appear at the hilum; and a fissure at the hilum frequently becomes enlarged and more refractive. The bubble is very persistent, it usually does not expand much, but occasionally considerable expansion occurs followed by rapid gelatinization. The lamellæ do not become more distinct at once but occasionally a few are more sharply defined previous to gelatinization. The entire grain becomes very refractive, and a border of greater refractivity is formed around the margin; this may broaden considerably and become very well defined. The methods of gelatinization are quite varied. In the most rapidly gelatinized grains a delicate fissure either proceeds from or intersects the hilum, followed by gelatinization of the mesial region before the refractive border; if the hilum is eccentric the most resistant portion of this border is a narrow band at the proximal end; gelatinization may start either at the distal margin when the hilum is quite eccentric, or at both ends if the hilum is centric or but slightly eccentric, in the former a narrow band at the proximal end and sides nearby is the most resistant and in the latter a narrow band on either side of the centric

or nearly centric hilum is the most resistant. The grains now assume a pitted appearance followed by the breaking of the starch into irregular refractive masses and granules previous to gelatinization. In all methods refractive granules may precede complete gelatinization, and in the grains where the reaction begins at one or two ends, well-defined fissures often proceed either from the hilum or intersect this region, and become quite deep and branched at the one or two extremities. As the reaction approaches the proximal end and sides nearby, it is quite characteristic for one side to gelatinize more quickly than the other. The narrow resistant band of starch is often penetrated by deep, short fissures previous to breaking into linear granules. The capsule is delicate and is much distorted and considerably distended during the process. The gelatinized grains are swollen and slightly to considerably distorted so that they do not bear much resemblance to the form of the untreated grain.

The reaction with *chromic acid* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 67 per cent of the grains and 97 per cent of the total starch in 15 minutes; in about 80 per cent of the grains and 98 per cent of the total starch in 20 minutes; in 100 per cent of the grains and total starch in 25 minutes. (Chart D 23.)

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in about 5 per cent of the grains and 6 per cent of the total starch in 5 minutes; in about 30 per cent of the grains and 65 per cent of the total starch in 15 minutes; in about 57 per cent of the grains and 86 per cent of the total starch in 30 minutes; in about 75 per cent of the grains and 90 per cent of the total starch in 45 minutes; in about 90 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 24.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 7 per cent of the grains and 12 per cent of the total starch in 15 minutes; in about 11 per cent of the grains and 40 per cent of the total starch in 30 minutes; in about 18 per cent of the grains and 48 per cent of the total starch in 45 minutes; in about 20 per cent of the grains and 53 per cent of the total starch in 60 minutes. (Chart D 25.)

The hilum swells but no bubble is seen there. The entire grain becomes very refractive and the lamellæ do not usually become any more distinct, with the exception of one clear lamella which is sometimes observed forming a line of demarcation between the main body of the grain and a border which is little if any more refractive than the rest of the grain. One or two fissures, according to the shape of the grain, either proceed from the hilum when it is quite eccentric, or one fissure may intersect the hilum if this point is centric or slightly eccentric. These fissures are usually deep and often much branched. Gelatinization of the grain is much varied and is often followed by partial and sometimes complete solution. In grains with an eccentric hilum gelatinization starts at the distal margin and advances towards the proximal end; a band at the proximal end and sides nearby being the most resistant, one side of the proximal end gelatinizing before the other. In many grains, notably those of a rounded or ellipsoidal type, the reaction spreads quite rapidly through the mesial region with the appearance of irregularly massed very refractive granules, a very refractive border becomes profusely striated and the outer lamellæ are broken down into linearly arranged refractive granules; the granules of one outermost lamella may prove very resistant and in some grains the capsule after much distention may be ruptured and deeply slashed at several points. The reaction may start in the marginal border and extend around the entire grain, sometimes with some ruffling, but more frequently the outermost lamella is broken into linearly arranged refractive granules which are very resistant. In elongated grains with a centric or slightly eccentric hilum the process may start almost simultaneously at both ends and then advance towards the hilum, a narrow band for a short distance at either side of the hilum proving the most resistant. All the methods of gelatinization are preceded by the disorganization of the starch into very refractive granules.

The gelatinized grains are swollen and slightly to considerably distorted. Many grains are but partially gelatinized, a refractive band and very refractive granules often proving resistant, and some of the grains are but slightly affected by the reagent beyond the fissuration already noted at the beginning of the reaction.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 28 per cent of the entire number of grains and 60 per cent of the total starch in 5 minutes; in about 72 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 94 per cent of the grains and 99 per cent of the total starch in 30 minutes. (Chart D 26.)

The reaction with *hydrochloric acid* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 12 per cent of the grains and 25 per cent of the total starch in 15 minutes; in about 15 per cent of the grains and 33 per cent of the total starch in 30 minutes; in about 21 per cent of the grains and 43 per cent of the total starch in 45 minutes; in about 29 per cent of the grains and 58 per cent of the total starch in 60 minutes. (Chart D 27.)

The reaction with *potassium hydroxide* begins in a few grains immediately. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 14 per cent of the grains and 35 per cent of the total starch in 15 minutes; in about 16 per cent of the grains and 48 per cent of the total starch in 30 minutes; in about 28 per cent of the grains and 54 per cent of the total starch in 45 minutes; in about 32 per cent of the grains and 56 per cent of the total starch in 60 minutes. (Chart D 28.)

The reaction with *potassium iodide* begins in a very few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; very slight progress in 15 minutes; and in about 1 per cent of the grains and 2 per cent of the total starch in 30 minutes; in about 2 per cent of the grains and 4 per cent of the total starch in 45 minutes; in about 3 per cent of the grains and 8 per cent of the total starch in 60 minutes. (Chart D 29.)

The hilum swells and if fissured the clefts become enlarged and more refractive but no bubble is found. The entire grain becomes very refractive and the lamellæ do not usually become any more distinct, with the exception of one which may serve as a line of demarcation between the main body of the grain and a border of slightly greater refractivity. If fissures are not present in the untreated grain, one or two may form which proceed from the hilum or intersect this region according to its location in the grain; these fissures often become branched; and in some grains numerous delicate fissures may radiate from the entire circumference of the hilum. Gelatinization is varied in character. In the most rapidly gelatinized grains the process quickly advances from the hilum along the course of the fissures; if the hilum is quite eccentric the process starts at the distal margin and advances toward the proximal end, a narrow band of starch at the proximal end and sides nearby proving the most resistant; in elongated grains with centric or but slightly eccentric hilum the process may start almost simultaneously from both ends and advance towards the hilum, a narrow band of starch at either side of the hilum proving the most resistant. When the refractive border is very sharply defined the reaction may start in this area and spread through the border without the appearance of refractive granules. Gelatinization is usually preceded by the appearance of very refractive granules which are massed in the mesial region, but often linearly arranged at the margin, notably the proximal end and sides nearby; and these linear granules usually bound the margin of the main body of the grain when the refractive border is gelatinized without the appearance of such granules. The gelatinized grains are swollen and slightly to considerably distorted, so that they do not usually resemble the untreated grain. Most of the grains are but little affected, and others have been disorganized into granules but have proceeded no further.

The reaction with *potassium sulphocyanate* begins in a few grains in half a minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 10 per cent of the grains and 13 per cent of the total starch in 30 minutes; in about 18 per cent of the grains and 43 per cent of the total starch in 45 minutes; in about 31 per cent of the grains and 46 per cent of the total starch in 60 minutes. (Chart D 30.)

The hilum enlarges slightly and becomes very distinct, but no bubble is found there, and, if the hilum of the untreated grain is fissured, the grains become more prominent and extend more widely, transversely or obliquely. The lamellæ in most grains gradually become more distinct and often remain, but in other grains they are obscured by fine striæ radiating from the hilum to the margin. Gelatinization begins in some less resistant grains by the appearance of a longitudinal fissure, not present in the untreated grain, which extends from the hilum almost to the distal margin and gives off many branches, and these divide this part of the grain into many small granules, while in others fissuration and striation may begin at the hilum and at the distal margin simultaneously. In the more resistant grains, which are few in number, fissuration and granulation begin at the distal margin. In the first class of grains, gelatinization progresses moderately rapidly in the granular portion to the distal margin, while the more resistant material at the proximal end becomes striated as the grain swells; with the progress of the reaction this proximal starch is pushed to the margin and forms a band consisting of several rows of granules which are very resistant and persist for some time. In the second class of grains the procedure is the same except that fissuration and granulation extend from the hilum and from the distal margin toward one another. In the third class fissuration and granulation proceed only from the margin and are followed by gelatinization from the distal margin upward, the proximal material, however, becomes striated, then divided into rows of granules which are not completely gelatinized at the end of an hour. The gelatinized grains are large and usually considerably distorted, often having but little resemblance to the untreated grains.

The reaction with *potassium sulphide* begins in rare grains in 5 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in still less than 0.5 per cent of the grains and total starch in 15 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 30 minutes; with very little if any progress in 45 and 60 minutes. (Chart D 31.)

The reaction with *sodium hydroxide* begins in rare grains in half a minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 6 per cent of the grains and 15 per cent of the total starch in 30 minutes; in about 8 per cent of the grains and 22 per cent of the total starch in 45 minutes; in about 11 per cent of the grains and 24 per cent of the total starch in 60 minutes. (Chart D 32.)

The reaction with *sodium sulphide* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 30 minutes; with little if any further progress in 45 and 60 minutes. (Chart D 33.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 7 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 52 per cent of the grains and 57 per cent of the total starch in 15 minutes; in about 93 per cent of the grains and 98 per cent of the total starch in 30 minutes; in about 98 per cent of the grains and 99 per cent of the total starch in 45 minutes. (Chart D 34.)

A small bubble appears at the hilum which in the majority of grains is not inclosed within a fissure; however, a cleft is moderately often present which becomes enlarged and more refractive. The bubble at the hilum may expand considerably before expulsion. The lamellæ do not become more distinct excepting in a few grains. A refractive border is formed which is usually not sharply defined from the rest of the grain. Gelatinization starts from the distal margin in the grains which have a well-marked proximal and distal end, then fre-

quently follows at the proximal end, while in some grains it advances to the proximal end before gelatinization starts at this end, a narrow band at the proximal end and sides nearby proving the most resistant starch. In grains with centric or nearly centric hilum the reaction starts almost simultaneously at both ends. The process advances from two ends towards the hilum in the majority of grains, a narrow band of starch at either side just distal to the hilum usually proving the most resistant. In rounded grains the refractive border is sometimes gelatinized without distortion. A fissure is found in some grains which form the hilum previous to gelatinization, and usually as the process approaches the hilum a fissure is not present; one is formed which then pushes through the more resistant starch surrounding the hilum. The gelatinized grains are swollen and much distorted so that they do not resemble the untreated grain.

The reaction with *calcium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; slight progress in 15 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 30 minutes; slight progress in 45 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 60 minutes. (Chart D 35.)

The reaction with *uranium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; very slight progress in 15 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 30 minutes; little if any further progress in 45 and 60 minutes. (Chart D 36.)

The reaction with *strontium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 30 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 45 minutes; in about 4 per cent of the grains and 7 per cent of the total starch in 60 minutes. (Chart D 37.)

The reaction with *cobalt nitrate* begins in very rare grains in 1 minute. Complete gelatinization occurs in much less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in still less than 0.5 per cent of the grains and total starch in 15 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 30 minutes; little if any further progress in 45 and 60 minutes, respectively. (Chart D 38.)

The reaction with *copper nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; little if any further progress in 30, 45, and 60 minutes, respectively. (Chart D 39.)

The reaction with *cupric chloride* begins in very rare grains in 1 minute. Complete gelatinization occurs in much less than 0.5 per cent of the entire number of grains and the total starch in 5 minutes; in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 15 minutes; little if any further progress in 30, 45, and 60 minutes, respectively. (Chart D 40.)

The reaction with *barium chloride* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; still but rare grains completely gelatinized and the reaction begun in but few grains in 15, 30, 45, and 60 minutes, at the end of which period complete gelatinization still occurs in less than 0.5 per cent of the grains and total starch. (Chart D 41.)

The reaction with *mercuric chloride* begins in very rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 30 minutes; little if any further progress in 45 and 60 minutes. (Chart D 42.)

Hippeastrum cleonia (Pollen Parent).

(Plate 1, fig. 8; Charts D 22 to D 42.)

Histologic Properties.

In *form* the grains are usually simple and isolated, but a larger number of both compound grains and of aggregates are observed in this starch than in that of *H. titan*, and there are also a number of isolated grains each having a large pressure facet at the distal end, no such grains being observed in *H. titan*. The grains are, as a rule, more rounded and more irregular than those of *H. titan*. The irregularities are due to the following causes: (1) Various shallow depressions in and flattenings of the margin; (2) small nipple-like and larger rounded and pointed projections; (3) some unequal development of one part of the distal end. The conspicuous forms are: Ovoid (usually rather broad but with one pointed end, although somewhat elongated forms and forms with both ends blunt and rounded occur), plano-convex and dome-shaped, round and nearly round, and elliptical. There are also reniform, finger-like, triangular, lenticular, and quadrilateral forms with rounded corners. The chief differences in form between this starch and that of *H. titan* are that the grains of this starch are somewhat more rounded and more irregular in form. The two starches resemble one another closely.

The *hilum*, when not fissured, is not very distinct and appears as a round or lenticular spot. It is fissured moderately often, but probably not so much as the grains of *H. titan*. The fissures take the following forms: (1) A single, moderately straight line often with several small fissures branching from it; (2) an occasional cruciform or Y-shaped fissure. The hilum is often centric, but usually eccentric, and the degree of eccentricity varies from 0.45 to 0.25, usually 0.39, of the longitudinal axis. The hilum is on the average less eccentric than in *H. titan*.

The *lamellæ* are often indistinct, but are distinct on more grains and more regular than was noted in the starch of *H. titan*. When they can be seen they are distinct, rather coarse bands usually having the form of the outline of the grain, even when near the hilum. They are usually continuous throughout the grain, but occasionally only near the hilum, and in some grains a few discontinuous lamellæ may be seen surrounded by several continuous ones. Those counted on the common-

sized and larger grains varied from 8 to 12 in number, usually 10. The number of lamellæ on the grains of this starch and of *H. titan* is usually the same.

The *size* of the grains varies from the smaller, which are 5 by 5μ, to the larger elongated forms, which are 42 by 26μ or rarely 48 by 30μ, and the larger broader forms, which are 46 by 44μ, rarely 50 by 44μ, in length and breadth. The common sizes are 30 by 22μ, 30 by 30μ, and 28 by 24μ in length and breadth. On the whole, they are larger than in *H. titan*.

Polariscopic Properties.

The *figure* is centric to very eccentric, the mean is eccentric, slightly less than in *H. titan,* and it is usually as distinct and clean cut as in *H. titan.* The lines vary from fine to moderately coarse, and they are arranged as in *H. titan,* although they intersect at right angles a little more frequently than in that species. The lines are more frequently straight with broadening at the margin than in *H. titan,* yet they are sometimes either bent or bisected, a little less frequently than in *H. titan.* Double and multiple figures are somewhat more numerous than in *H. titan.*

The *degree of polarization* is high to very high (value 80). The range of polarization is from moderately high to high, as in *H. titan,* but there is a greater number of the moderately high, hence the mean is slightly lower than in that species. There is the same variation in polarization in the same aspect of a given grain as in *H. titan.*

With *selenite* the quadrants are generally well defined, usually unequal in size, and while regular in the majority of grains, irregularity is not uncommon. The equality of size is a little more frequent and the irregularity in shape a little less frequent than in *H. titan.* The colors are generally pure, but not so often pure as in *H. titan.*

Iodine Reactions.

With 0.25 Lugol's solution the grains immediately color a moderate to moderately deep blue-violet (value 55), a little deeper and a little more bluish in tint than in *H. titan;* the color deepens quickly from deep to very deep, becoming more blue in tint. With 0.125 Lugol's solution the grains color a moderately light blue-violet, a little lighter and more bluish in tint than in *H. titan;* and they quickly deepen from moderate to deep, a little deeper than in *H. titan.* After heating in water until all the grains are gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* color a light to deep blue, the mean being moderate to moderately deep, decidedly deeper than in *H. titan;* the color is usually a pure blue, but more with reddish tint appear than in *H. titan;* the starch *solution* becomes a deep indigo-blue, the same as in *H. titan.* If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution the *grain-residues* color from light to deep blue usually tinged with red, the majority of the grains are moderately colored but more of the deep are found than in *H. titan,* hence the mean is little deeper than in *H. titan.* The *capsules* color a moderately deep old-rose, deeper and more reddish in tint than in *H. titan;* the *solution* becomes a very deep indigo-blue as in *H. titan.*

Aniline Reactions.

With *gentian violet* the grains stain very lightly at once a little deeper than in *H. titan,* and in half an hour they become moderate in depth (value 50), deeper than in *H. titan.*

With *safranin* the grains color very lightly at once (a little deeper than in *H. titan*), and in half an hour they become moderate with a few moderately deep (value 55), a little deeper than in *H. titan.*

Temperature Reactions.

The majority of the grains are gelatinized at 71° to 73° C., and all but very rare grains at 73° to 74° C., mean 73.5 C. The mean temperature is lower (3.75°) than in *H. titan.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 8 per cent of the total starch in 5 minutes; in about 25 per cent of the grains and 30 per cent of the total starch in 15 minutes; in about 39 per cent of the grains and 44 per cent of the total starch in 30 minutes; in about 44 per cent of the grains and 50 per cent of the total starch in 45 minutes; in about 47 per cent of the grains and 55 per cent of the total starch in 60 minutes. (Chart D 22.) One or more bubbles more frequently form at the hilum and are very persistent and expand less than in *H. titan.* A fissure at the hilum may become enlarged and more refractive but much less frequently than in *H. titan.* The lamellæ do not become more sharply defined and the entire grain becomes refractive, often with a border of greater refractivity around the main body of the grain as in *H. titan.* The methods of gelatinization are similar to those observed in *H. titan,* but the pitted appearance of the grain preceding gelatinization is more common, and the starting point at the distal margin with advancement toward the proximal end is less frequent. The fissures formed during the process are not quite so deep, nor the refractive granules so resistant as in *H. titan.* The capsule is much distorted and considerably distended during the process, even more so than in *H. titan.* The gelatinized grains are swollen and much distorted, more of the latter than in *H. titan.* They bear even less resemblance to the form of the untreated grain than in *H. titan.*

The reaction with *chromic acid* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 22 per cent of the grains and 80 per cent of the total starch in 15 minutes; in about 67 per cent of the grains and 96 per cent of the total starch in 20 minutes; in about 99 per cent of the grains and in more than 99 per cent of the total starch in 25 minutes. (Chart D 23.)

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in about 45 per cent of the grains and 70 per cent of the total starch in 15 minutes; in about 75 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 83 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about

96 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 24.)

The reaction with *nitric acid* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 20 per cent of the entire number of grains and 25 per cent of the total starch in 15 minutes; in about 28 per cent of the grains and 49 per cent of the total starch in 30 minutes; in about 32 per cent of the grains and 60 per cent of the total starch in 45 minutes; in about 40 per cent of the grains and 75 per cent of the total starch in 60 minutes. (Chart D 25.)

The hilum swells but no bubble was detected thereat as in *H. titan.* The entire grain becomes very refractive, and the definition of the lamellæ and refractive border are about the same as in *H. titan.* Fissures of a similar character are formed but they are not so deep nor so much branched as in *H. titan.* The various methods of gelatinization noted in *H. cleonia* are observed; but the reaction starts at the distal margin and advances towards the proximal end in fewer grains, and the pitted appearance preceding gelatinization and the slashing of the capsule at several points at the end of gelatinization is found in more grains than in *H. titan.* Gelatinization is preceded by the formation of very refractive granules which are much less resistant than in *H. titan,* and partial or complete solution may follow gelatinization as in *H. titan.*

The gelatinized grains are swollen and slightly to considerably distorted as in *H. titan.* Many grains are but partially gelatinized and others have been little affected beyond the fissuration of the grains, but more grains have advanced further in the process than in *H. titan.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 20 per cent of the entire number of grains and 50 per cent of the total starch in 5 minutes; in about 67 per cent of the grains and 88 per cent of the total starch in 15 minutes; in about 92 per cent of the grains and 98 per cent of the total starch in 30 minutes. (Chart D 26.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 22 per cent of the grains and 48 per cent of the total starch in 15 minutes; in about 40 per cent of the grains and 74 per cent of the total starch in 30 minutes; in about 60 per cent of the grains and 78 per cent of the total starch in 45 minutes; in about 65 per cent of the grains and 83 per cent of the total starch in 60 minutes. (Chart D 27.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 13 per cent of the grains and 19 per cent of the total starch in 5 minutes; in about 24 per cent of the grains and 48 per cent of the total starch in 15 minutes; in about 32 per cent of the grains and 58 per cent of the total starch in 30 minutes; in about 35 per cent of the grains and 63 per cent of the total starch in 45 minutes; in about 48 per cent of the grains and 65 per cent of the total starch in 60 minutes. (Chart D 28.)

The reaction with *potassium iodide* begins in a few grains in half a minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 8 per cent of the total starch in 30 minutes; in about 7 per cent of the grains and 10 per cent of the total starch in 45 minutes; in about 9 per cent of the grains and 15 per cent of the total starch in 60 minutes. (Chart D 29.)

The hilum swells slightly and occasional fissures located here become enlarged and refractive, but less prominent than in *H. titan;* no bubble is detected at the hilum, as in *H. titan.* The entire grain becomes very refractive, and the appearance of one lamella and of a border of greater refractivity around the main body of the grain are observed in *H. titan.* New fissures are formed of a similar character but not quite so deep as in *H. titan.* The methods of gelatinization are varied as in *H. titan,* but the process does not so frequently start at the distal end; it advances toward the proximal end, and in some grains a pitted appearance precedes gelatinization. In grains in which the border is very prominent a number of fissures may form within this area, followed by the breaking into segments of the marginal lamella of the border or of the lamella forming a demarcation between the border and the main body of the grain. This method of gelatinization is followed either by the slashing of the capsule at various points or of its becoming considerably distorted when these segments are present in the boundary of the main body of the grain. The method of gelatinization just described was not observed in *H. titan.*

The gelatinized grains are swollen and somewhat to considerably more distorted than in *H. titan* so that they do not resemble the untreated grain as in *H. titan.* Many grains are but little affected and others have been disorganized into granules but have not proceeded further; fewer grains remain unaffected and more are disorganized than in *H. titan.*

The reaction with *potassium sulphocyanate* begins in a few grains in half a minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 8 per cent of the total starch in 15 minutes; in about 15 per cent of the grains and 22 per cent of the total starch in 30 minutes; in about 25 per cent of the grains and 54 per cent of the total starch in 45 minutes; in about 42 per cent of the grains and 60 per cent of the total starch in 60 minutes. (Chart D 30.)

The hilum, as in *H. titan,* enlarges somewhat, but no bubble is detected; the fissure in the untreated grain, if present, becomes more prominent and extends more widely, obliquely, transversely, or longitudinally. It may either proceed from or intersect the hilum. If no fissures are present in the untreated grain, new ones are found, and these are usually longitudinal in direction and often branched. The lamellæ gradually become more distinct than in *H. titan,* and, as a rule, remain so until near the end of the reaction. Gelatinization begins in the less-resistant grains as in those of *H. titan,* and proceeds in the same manner; while in the more resistant grains, of which there are more than in *H. titan,* gelatinization begins at the distal end with considerable swelling and distention of the capsule not noted in *H. titan,* but from this point on the process is the same as in *H. titan.*

The gelatinized grains are large and considerably distorted, but retain some of the form of the untreated grain.

The reaction with *potassium sulphide* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 30 minutes; slight advance in 45 minutes; in about the same percentage of the grains and 3 per cent of the total starch in 60 minutes. (Chart D 31.)

The reaction with *sodium hydroxide* begins in a few grains in half a minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 10 per cent of the grains and 23 per cent of the total starch in 30 minutes; in about 16 per cent of the grains and 25 per cent of the total starch in 45 minutes; in about 20 per cent of the grains and 28 per cent of the total starch in 60 minutes. (Chart D 32.)

The reaction with *sodium sulphide* begins in a few grains in half a minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 6 per cent of the grains and 9 per cent of the total starch in 30 minutes; in about 7 per cent of the grains and 10 per cent of the total starch in 45 minutes; in about 11 per cent of the grains and 13 per cent of the total starch in 60 minutes. (Chart D 33.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 13 per cent of the grains and 16 per cent of the total starch in 5 minutes; in about 80 per cent of the grains and 85 per cent of the total starch in 15 minutes; in about 99 per cent of the grains and in more than 99 per cent of the total starch in 30 minutes. (Chart D 34.) A small bubble appears at the hilum, which is not inclosed within a fissure in most of the grains, much less frequently than in *H. titan,* and it expands much less than in that variety. The lamellæ become a little more distinct and the refractive border a little more prominent than in *H. titan.* A fissure less frequently proceeds from the hilum previous to the beginning of the process of gelatinization than in *H. titan.* Gelatinization often begins and proceeds as noted in *H. titan,* but it starts at the distal end less frequently than in that variety, proceeding toward the proximal end. The gelatinized grains are much swollen and much distorted, so that they do not resemble the untreated grain as in *H. titan.*

The reaction with *calcium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; slight progress in 30 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 45 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 60 minutes. (Chart D 35.)

The reaction with *uranium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 30 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 36.)

The reaction with *strontium nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; slight advance in 15 minutes; in about 3 per cent of the entire number of grains and 5 per cent of the total starch in 30 minutes; in about 4 per cent of the grains and 8 per cent of the total starch in 45 minutes; in about 8 per cent of the grains and 16 per cent of the total starch in 60 minutes. (Chart D 37.)

The reaction with *cobalt nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; complete gelatinization occurs in 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 30 minutes; little if any further progress in 45 and 60 minutes. (Chart D 38.)

The reaction with *copper nitrate* begins in about half a minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; slight progress in 15 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 30 minutes; little if any further progress in 45 and 60 minutes. (Chart D 39.)

The reaction with *cupric chloride* begins in very rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; still in less than 0.5 per cent of the grains and total starch in 15 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 30 minutes; very little if any further progress in 45 and 60 minutes. (Chart D 40.)

The reaction with *barium chloride* begins in very rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; still less than 0.5 per cent of the grains and total starch in 15 minutes; little if any further progress in 30, 45, and 60 minutes, respectively. (Chart D 41.)

The reaction with *mercuric chloride* begins in very rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the grains and total starch in 5 minutes; slight progress in 15 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes, respectively. (Chart D 42.)

Hippeastrum titan-cleonia (Hybrid).

(Plate 1, fig. 9; Charts D 22 to D 42.)

Histologic Properties.

In *form* the grains are usually simple and isolated, but compound grains and aggregates occur about as frequently as in *H. titan* and are of the same character as those noted under both parents. The grains are not so irregular in form as those of *H. cleonia* but slightly more irregular than those of *H. titan.* The irregularities

are due to the same causes as noted under the parents. The conspicuous forms are ovoid (with either one pointed end or both ends blunted), round and nearly round forms, and elliptical. There are also plano-convex and dome-shaped, triangular, quadilateral with rounded corners, lenticular forms, and reniform. These grains are slightly nearer to *H. titan* in form, but very few differences are to be noted either between the parents or the parents and the hybrid.

The *hilum*, when not fissured, is not very distinct, as in the parents; it is more frequently fissured and the fissures are more extensive than in either parent, in which respect it is nearer *H. titan* than *H. cleonia*. The fissures have the following forms: (1) A single, straight or angled line with smaller fissures branching from it; (2) cruciform or Y-shaped; (3) an irregular, curved line; (4) a single, straight line with no branches. The hilum is sometimes centric but is usually eccentric from 0.46 to 0.3, commonly 0.36. In the character and eccentricity of the hilum *H. titan-cleonia* is slightly nearer to *H. titan* than to *H. cleonia*.

The *lamellæ* are more frequently distinct and more regular than in *H. titan*, and in this respect they are nearer to *H. cleonia*. In all other respects they are practically identical with those of both parents. The number counted on some of the common-sized and large grains varies from 8 to 14, usually 11 to 12. In the character of the lamellæ *H. titan-cleonia* is slightly nearer to *H. cleonia* than to *H. titan*, but the number is the same or practically the same as in all these starches.

The *size* of the grains varies from the smaller which are 5 by 5μ, to the larger, more elongated forms which are 42 by 26μ or, rarely, 48 by 30μ, and the larger broader forms, which are 46 by 44μ, rarely, 50 by 44μ in length and breadth. The common sizes are 30 by 22μ, 30 by 30μ, and 28 by 24μ in length and breadth. The grains of the hybrid are much nearer *H. cleonia* in size, but, on the whole, larger than those of either parent.

Polariscopic Properties.

The *figure* varies from centric to very eccentric, the mean is eccentric, very close to that of both parents, but somewhat nearer to *H. titan*. The figure is usually distinct and clean-cut as in the parents. The lines vary from fine to moderately coarse and are arranged as in the parents, but a somewhat larger number of grains have the lines intersecting at right angles. The lines are more frequently straight with broadening at the margin, yet they are sometimes bent and bisected, a little less frequently than in *H. titan*, but the same as in *H. cleonia*. Double and multiple figures are moderately frequent, the same as in *H. titan*, a little less numerous than in *H. cleonia*.

The *degree of polarization* is high to very high (value 85); higher than in the parents but nearer to *H. titan*. The range of polarization is not so great as in the parents; and the variation of polarization in the same aspect of a given grain is the same as in the parents.

With *selenite* the quadrants are usually well defined, and the definition is sharper in a larger number of grains than in the parents. The quadrants are usually unequal in size, though more with equal quadrants are found than in the parents, in which respect the hybrid is closer to *H. cleonia*. The quadrants are regular in shape in the majority of grains, yet irregularity is about as frequently observed as in *H. titan*, a little more frequent than in *H. cleonia*. The colors are usually pure, the purity is more frequent than in the parents, but is closer to *H. titan*.

In the degree of polarization, the character of the figure, and the appearances with selenite *H. titan-cleonia* is somewhat closer to *H. titan* than to *H. cleonia*, although the hybrid and the parents are very close to one another. A character which appears in either parent may be further developed in the hybrid.

Iodine Reactions.

With 0.25 Lugol's solution the grains color at once a moderate to deep (value 58) blue-violet, a little deeper and more bluish than in either parent, but nearer *H. cleonia* than *H. titan*; the grains quickly deepen from dark to very dark, becoming more blue. With 0.125 per cent Lugol's solution the grains color a moderately light blue-violet at once, a little deeper than *H. titan*, about the same depth as in *H. cleonia*; and the color deepens quickly from moderate to deep, the same depth as in *H. cleonia*. After heating in water until the grains are gelatinized and then adding a 2 per cent Lugol's solution, the gelatinized *grains* color a light to deep blue, a few with reddish tint, most of the grains are light, hence the mean is moderately light to moderate, a little deeper but about the same purity of color as in *H. titan*, and a little lighter and purer than in *H. cleonia*. The starch *solution* colors a deep indigo-blue, about the same as the parents. If the preparation is boiled for 2 minutes, and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* color a light to deep blue, usually tinged with red, the mean is moderate to moderately deep, a little deeper and more reddish than in *H. titan*, and of the same depth and tint as in *H. cleonia*. The *capsules* color from light to deep old-rose, the mean is moderate to moderately deep, not quite so deep nor so reddish as in *H. cleonia*, but a deeper and more reddish tint than in *H. titan*, but not quite so deep as in *H. cleonia*. The starch *solution* colors a very deep indigo-blue, about the same depth as in the parent. Qualitatively and quantitatively the reaction with iodine indicates a somewhat closer relationship to *H. cleonia* than to *H. titan*.

Aniline Reactions.

With *gentian violet* the grains color very lightly at once a little deeper than in *H. titan*, the same as *H. cleonia*; and in about half an hour they become moderately colored (value 50), deeper than in *H. titan* but the same as in *H. cleonia*.

With *safranin* the grains stain very lightly at once, a little deeper than in *H. titan*, about the same as *H. cleonia*, and in half an hour they become moderate with a few moderately deep (value 55), deeper than *H. titan*; but the same as in *H. cleonia*.

The reactions with anilines exhibit a closer resemblance to *H. cleonia* than to *H. titan*.

Temperature Reactions.

The majority of the grains are gelatinized at 72° to 74° C. and of all at 73° to 74° C., mean 73.5° C. The mean temperature is lower than in *H. titan* (77.25°) and the same as in *H. cleonia*.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 7 per cent of the grains and 14 per cent of the total starch in 15 minutes; in about 14 per cent of the grains and 21 per cent of the total starch in 30 minutes; in about 18 per cent of the grains and 25 per cent of the total starch in 45 minutes; in about 25 per cent of the grains and 29 per cent of the total starch in 60 minutes. (Chart D 22.)

One or more bubbles appear at the hilum, more frequently only 1, as in the parents; this bubble is very persistent as in the parents, but expands more frequently to greater size than in the parents, in which aspect the grains are nearer to *H. titan.* A fissure at the hilum (which becomes enlarged and more refractive) is more frequently observed than in either parent, but this phenomenon is more frequent in *H. titan* than in *H. cleonia.* The lack of sharper definition of the lamellæ, the refractivity of the entire grain, and the presence of a marginal border of greater refractivity than the main body of the grain are all similar to what is observed in the parents. The same methods of gelatinization are observed as noted in the parents; but not quite so many grains are at first gelatinized at the distal margin as in *H. titan,* but more than in *H. cleonia;* and the punctated appearance of the grain previous to gelatinization is more frequent than in either parent, but nearer to that of *H. cleonia.* The appearance of fissures and of refractive granules during the process is found nearly as often as in *H. titan* and much more often than in *H. cleonia.*

The gelatinized grains are swollen, and from slightly to much distorted, a little more than in *H. titan,* but not quite so much as in *H. cleonia.* In this reaction *H. titan-cleonia* shows qualitatively a very close relationship to both parents, but is somewhat closer to *H. titan* than to *H. cleonia.* A character appearing in one parent may be accentuated in the hybrid.

The reaction with *chromic acid* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 24 per cent of the grains and 50 per cent of the total starch in 15 minutes; in about 35 per cent of the grains and 70 per cent of the total starch in 20 minutes; in about 50 per cent of the grains and 85 per cent of the total starch in 25 minutes; in about 67 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 75 per cent of the grains and 98 per cent of the total starch in 35 minutes; in 100 per cent of the grains and total starch in 40 minutes. (Chart D 23.)

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 25 per cent of the grains and 55 per cent of the total starch in 15 minutes; in about 62 per cent of the grains and 75 per cent of the total starch in 30 minutes; in about 75 per cent of the grains and 88 per cent of the total starch in 45 minutes; in about 90 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 24.)

The reaction with *nitric acid* begins in a few grains in half a minute. Complete gelatinization occurs in about 2 per cent of the grains and 3 per cent of the total starch in 5 minutes; in about 9 per cent of the grains and 22 per cent of the total starch in 15 minutes; in about the same percentage of the grains and 42 per cent of the total starch in 30 minutes; in about 15 per cent of the grains and 53 per cent of the total starch in 45 minutes; in about 29 per cent of the grains and 62 per cent of the total starch in 60 minutes. (Chart D 25.)

The hilum swells but no bubble is detected thereat as noted in the parents. The entire grain becomes more refractive and occasionally a few or many of the lamellæ may become more distinct, the definition being sharper than in the parents. A refractive border is formed which is somewhat more prominent than in the parents. Fissures of a like character to those described in *H. titan* are observed; they are about as deep and profusely branched as in *H. titan;* but deeper and more branched than in *H. cleonia.* The various methods of gelatinization which occur in this variety are as described in *H. titan.* The most common course seems to proceed through the mesial region, the outermost lamellæ of the entire margin being more resistant than this central area, more frequently than in the parents, but more like the grains of *H. cleonia.* A pitted appearance of the entire grain sometimes precedes gelatinization, the refractive granules of such grains and the striation of the outermost lamellæ being even more marked than in the parents, but more like in *H. cleonia.* Gelatinization frequently begins at the distal margin and advances towards the proximal end, not quite so often as in *H. titan* but more frequently than in *H. cleonia.* Gelatinization is preceded by the formation of refractive granules which are not quite so resistant as in *H. titan,* but much more so than in *H. cleonia.* The capsules are rarely slashed at several points after the completion of the reaction, less frequently than in either parent, but more like the grains of *H. titan.*

The gelatinized grains are swollen and slightly to considerably distorted as in the parents. Many grains are but partially gelatinized while many others have not advanced beyond the initial stages of the process, not quite so many as in *H. titan,* but decidedly more than in *H. cleonia.*

In this reaction *H. titan-cleonia* shows qualitatively a closer relationship to both parents, but is somewhat closer to *H. titan* than to *H. cleonia.* A characteristic appearing in the parents is frequently accentuated in the offspring.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 36 per cent of the entire number of grains and 62 per cent of the total starch in 5 minutes; in about 85 per cent of the grains and 96 per cent of the total starch in 15 minutes; in more than 99 per cent of both the grains and total starch in 30 minutes. (Chart D 26.)

The reaction with *hydrochloric acid* begins in a few grains immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 14 per cent of the grains and 28 per cent of the total starch in 15 minutes; in about 25 per cent of the grains and 49 per cent of the total starch in 30 minutes; in about 30 per cent of the grains and 57 per cent of the total

starch in 45 minutes; in about 37 per cent of the grains and 62 per cent of the total starch in 60 minutes. (Chart D 27.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 15 per cent of the grains and 20 per cent of the total starch in 5 minutes; in about 31 per cent of the grains and 60 per cent of the total starch in 15 minutes; in about 43 per cent of the grains and 67 per cent of the total starch in 30 minutes; in about 51 per cent of the grains and 72 per cent of the total starch in 45 minutes; in about 60 per cent of the grains and 76 per cent of the total starch in 60 minutes. (Chart D 28.)

The reaction with *potassium iodide* begins in a very few grains in half a minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 4 per cent of the total starch in 30 minutes; in about 4 per cent of the grains and 6 per cent of the total starch in 45 minutes; in about 5 per cent of the grains and 10 per cent of the total starch in 60 minutes. (Chart D 29.)

The hilum swells slightly and the fissures become enlarged and more refractive as noted in both parents; the enlarged fissure is more frequent than in either parent, but closer to that observed in the grains of *H. titan.* No bubble was detected at the hilum as in both parents. The entire grain becomes very refractive as in the parents, but the lamellæ and the refractive border are demonstrable in more grains than in the parents. The fissures are of similar character and arrangement to those noted in the parents, but they are somewhat deeper; thus more closely resembling those of *H. titan.* The methods of gelatinization are the same as in the parents; not quite so many grains are gelatinized from the distal margin to the proximal end as in *H. titan,* but more than in *H. cleonia.* The pitted or punctated appearance of the grain previous to gelatinization is more common than in the parents, but more closely resembles that noted in *H. cleonia.* The breaking of the marginal lamella into segments and the slashing of the capsule was not noted, in which respect *H. titan-cleonia* more closely resembles *H. titan.*

The gelatinized grains are swollen and slightly to considerably distorted, a little more than in *H. titan,* but less than in *H. cleonia.* Many grains remain with granules and a large number, as in *H. titan,* are little if any affected beyond the swelling of the hilum, as in the parents.

In the reaction with potassium iodide *H. titan-cleonia* shows qualitatively a close relationship to the parents, but a little closer to *H. titan* than to *H. cleonia.* A characteristic appearing in a parent may be further developed in the hybrid.

The reaction with *potassium sulphocyanate* begins in a few grains in half a minute. Complete gelatinization occurs in about 1 per cent of the grains and 2 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 10 per cent of the grains and 20 per cent of the total starch in 30 minutes; in about 15 per cent of the grains and 39 per cent of the total starch in 45 minutes; in about 40 per cent of the grains and 56 per cent of the total starch in 60 minutes. (Chart D 30.)

The hilum, as in the parents, enlarges somewhat, but no bubble is detected and the appearance and arrangement of fissures are the same as in the parents. The lamellæ gradually become rather more distinct than in *H. titan,* but somewhat less distinct than in *H. cleonia.* Gelatinization begins and proceeds as in *H. titan,* the only difference noted being that the grains often assume a pitted appearance before gelatinization begins. This is noted in a few grains in *H. cleonia* and not at all in *H. titan.*

The gelatinized grains as in the parents are enlarged and considerably distorted, but retain some of the form of the untreated grain.

In the reaction with potassium sulphocyanate *H. titan-cleonia* shows qualitatively a closer relationship to *H. titan* than to *H. cleonia,* but the reactions of all these starches with this reagent are qualitatively very close.

The reaction with *potassium sulphide* begins in rare grains in 5 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; and in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; little if any further advance in 30, 45, and 60 minutes, respectively. (Chart D 31.)

The reaction with *sodium hydroxide* begins in rare grains in half a minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 15 per cent of the grains and 33 per cent of the total starch in 30 minutes; in about 22 per cent of the grains and 40 per cent of the total starch in 45 minutes; in about 25 per cent of the grains and 49 per cent of the total starch in 60 minutes. (Chart D 32.)

The reaction with *sodium sulphide* begins in very rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; slight advance in 30 and 45 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 60 minutes. (Chart D 33.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 51 per cent of the grains and 55 per cent of the total starch in 15 minutes; in about 92 per cent of the grains and 94 per cent of the total starch in 30 minutes; in about 100 per cent of the grains and total starch in 45 minutes. (Chart D 34.)

A small bubble appears at the hilum which in the majority of grains is not inclosed within a fissure; but a cleft appears at the hilum in more grains than in the parents and the bubble may expand considerably before expulsion; in this respect the hybrid is nearer to *H. titan* than to *H. cleonia.* The lamellæ and a refractive border become more sharply defined in more grains than in the parents, in this feature being a little closer to *H. cleonia.* Gelatinization begins and proceeds as in the parents, but the method of procedure in which the reaction starts at the distal margin and advances proximalward is not quite so frequent as in *H. titan,* but more commonly

observed than in *H. cleonia*. A delicate fissure proceeds from the hilum previous to the beginning of gelatinization in some grains; as in *H. titan*, but more frequently than in *H. cleonia;* and irregular fissures sometimes form throughout the main body of the grain, which were not noted in the parents.

The gelatinized grains are swollen and distorted so that they do not resemble the form of the untreated grain as in the parents.

In the reaction with sodium salicylate *H. titan-cleonia* shows qualitatively a very close relationship to both parents, but is somewhat closer to *H. titan* than to *H. cleonia*. Any characteristic which appears in one or both parents is often further developed in the hybrid.

The reaction with *calcium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; still in less than 0.5 per cent of the grains and total starch in 15 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes, respectively. (Chart D 35.)

The reaction with *uranium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the grains and 1 per cent of the total starch in 5 minutes; very slight progress in 15 and 30 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 36.)

The reaction with *strontium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 3 per cent of the total starch in 30 minutes; in about 2 per cent of the grains and 5 per cent of the total starch in 45 minutes; in about 3 per cent of the grains and 7 per cent of the total starch in 60 minutes. (Chart D 37.)

The reaction with *cobalt nitrate* begins in very rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the grains and total starch in 5 minutes; still less than 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about 0.5 per cent of the grains and total starch in 30 minutes; little if any further progress in 45 and 60 minutes, respectively. (Chart D 38.)

The reaction with *copper nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; little if any further progress in 30, 45, and 60 minutes, respectively. (Chart D 39.)

The reaction with *cupric chloride* begins in very rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; very slight progress in 15 minutes; and in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 30 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 45 minutes; little if any further progress in 60 minutes. (Chart D 40.)

The reaction with *barium chloride* begins in very rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; very slight progress in 15, 30, 45, and 60 minutes, until at the end of which period still less than 0.5 per cent of the entire number of grains and total starch is gelatinized. (Chart D 41.)

The reaction with *mercuric chloride* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; slight progress in 15 and 30 minutes; in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 45 minutes; little if any further progress in 60 minutes. (Chart D42.)

3. Starches of Hippeastrum ossultan, H. pyrrha, and H. ossultan-pyrrha.

Hippeastrum ossultan (Seed Parent).

(Plate 2, fig. 10; Charts D 43 to D 63.)

Histologic Properties.

In *form* the grains are usually simple and isolated, but there is a moderate number of compound grains which may consist of from 2 to 8 or more components, and also a few aggregates are noted consisting of 2 or 3 or more grains linearly arranged. The grains are moderately regular in form, but a perfect regularly formed grain is not common. The irregularities noted are due to the following causes: (1) A set of secondary lamellæ whose longitudinal axis is at an angle to that of the primary grain; (2) shallow depressions in and flattening of the margin; (3) small nipple-like protuberances; (4) 1, 2, or 3 pressure facets on the distal end and sides; (5) very irregular forms, due to an irregular mass of small grain forming a large compound grain. The conspicuous forms are: Round and nearly round, ovoid with one pointed end or with both ends blunt, and elliptical. There are also lenticular, irregularly quadrilateral, triangular, plano-convex, and modified reniform shapes.

The *hilum* is a round or lenticular spot and is moderately distinct and not often fissured. When the fissure occurs it takes the following forms: A small, indistinct, straight, angled, or curved line. The hilum is sometimes centric but is commonly eccentric 0.45 to 0.3, usually 0.38, of the longitudinal axis.

The *lamellæ* are usually not very distinct, but on many grains they are distinct and appear as rather coarse, continuous bands, all of which have the form of the outline of the grain, though this may be somewhat modified in individual cases. There are often grains in which a secondary deposit of starch has occurred, and the lamellæ of this secondary deposit may or may not be continuous, but are usually coarser and more distinct than those of the primary formation. The number counted on the common-sized and larger grains varies from 7 to 12, usually 10.

The grains vary in *size* from the smaller which are 4 by 4μ to the larger broader forms which are 44 by 38μ and the larger elongated forms which are 42 by 34μ and rarely 44 by 24μ in length and breadth. The common sizes are 26 by 26μ, and 30 by 24μ.

Polariscopic Properties.

The *figure* varies from centric to very eccentric, with the majority slightly eccentric. The lines vary

from fine to moderately coarse and become broader at the margin and usually intersect obliquely, but in some grains the lines intersect either at the right angles or are arranged in a median line with bisected ends. The lines are more frequently straight, but occasionally bent or bisected. Double figures are moderately numerous.

The *degree of polarization* is high to very high (value 83). The polarization in the different grains varies from moderately high to very high, and considerable variation may occur in the same aspect of a given grain.

With *selenite* the quadrants are well defined, usually unequal in size, and generally regular in shape. The colors are generally pure.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains immediately color a moderately light to moderate blue-violet (value 45); the color deepens until it is moderately deep to deep. With 0.125 per cent Lugol's solution the grains color a light blue-violet, and the color deepens quickly to moderately deep. After heating in water until the grains are gelatinized and then adding a 2 per cent Lugol's solution the *grains* color a light to deep blue, usually with a reddish tint, the mean is moderate in depth and the starch *solution* colors a deep indigo-blue. If the preparation is boiled for 2 minutes and then treated with a 2 per cent Lugol's solution the *grain-residues* color a light to deep blue usually tinged with red. The *capsules* color a moderate old-rose to moderate amethyst, the majority a moderate old-rose and the starch *solution* colors a very deep indigo-blue.

Aniline Reactions.

With *gentian violet* the grains stain at once very lightly; and in half an hour they are moderately colored (value 50).

With *safranin* the grains stain very lightly, and in half an hour they are moderate to moderately deep in color (value 55).

Temperature Reactions.

The majority of the grains are gelatinized at 73° to 74° C., and of all but rare grains at 75° to 76° C., mean 75.5° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in about 20 per cent of the grains and 27 per cent of the total starch in 15 minutes; in about 30 per cent of the grains and 37 per cent of the total starch in 30 minutes; in about 39 per cent of the grains and 42 per cent of the total starch in 45 minutes; in about 43 per cent of the grains and 45 per cent of the total starch in 60 minutes. (Chart D 43.)

One or more bubbles, more frequently the former, appear at the hilum; and a fissure is occasionally present at the hilum which becomes enlarged and more refractive. The lamellæ do not become any more distinct but the entire grain is more refractive and a slightly more refractive border is formed around the main body of the grain. A delicate fissure may proceed from or intersect the hilum which deepens and may branch as the reaction proceeds. The methods of gelatinization are varied. In the most rapidly gelatinized grains, the process may spread quickly through the mesial region, the refractive border, especially at the proximal end, being the more resistant. Gelatinization may start at the distal margin when the hilum is markedly eccentric; or from both ends in the long slender type with centric or nearly centric hilum. A pitted appearance may appear in an area of the marginal border directly underlying the capsule, followed by gelatinization of this area; the process may then spread through the grain, the more resistant starch being located in a narrow band at the proximal end and sides nearby. The starch through the mesial region is often disorganized with the appearance of irregularly arranged refractive granules along the course of the longitudinal fissure; and the most resistant starch is divided into granules linearly arranged following the formation of numerous short fissures or striæ in this area. The starch at one side of the proximal end is generally less resistant than that of the opposite side.

The gelatinized grains are swollen and considerably distorted, so that they do not resemble the form of the untreated grain.

The reaction with *chromic acid* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 25 per cent of the total starch in 15 minutes; in about 55 per cent of the grains and 90 per cent of the total starch in 20 minutes; in about 85 per cent of the grains and 96 per cent of the total starch in 25 minutes; in more than 99 per cent of both the grains and total starch in 30 minutes. (Chart D 44.)

The reaction with *pyrogallic acid* begins in a few grains in 1 minute. Complete gelatinization occurs in about 9 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 40 per cent of the grains and 67 per cent of the total starch in 15 minutes; in about 65 per cent of the grains and 80 per cent of the total starch in 30 minutes; in about 75 per cent of the grains and 90 per cent of the total starch in 45 minutes; in about 86 per cent of the grains and 95 per cent of the total starch in 60 minutes. (Chart D 45.)

The reaction with *nitric acid* begins in a few grains in half a minute. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 15 per cent of the grains and 17 per cent of the total starch in 15 minutes; in about 25 per cent of the grains and 30 per cent of the total starch in 30 minutes; in about 30 per cent of the grains and 43 per cent of the total starch in 45 minutes; in about the same percentage of grains and 56 per cent of the total starch in 60 minutes. (Chart D 46.)

The hilum swells but no bubble was detected thereat. If a fissure is found at the hilum it becomes enlarged and more refractive, but loses its refractivity without the appearance of a bubble. The entire grain becomes refractive and the lamellæ are not demonstrable with the exception of one which moderately often forms a demarcation between the main body of the grain and a border of slightly greater refractivity. Either one or two fissures, according to the shape of the grain, may proceed distally from the hilum, or when but one is present it may intersect this point. The progress of

the reaction is much varied and the disorganization of the starch is accompanied with the appearance of large refractive granules. These granules are massed and more numerous in the main body of the grain when a refractive border is present; but if no such border is observed and if the hilum is quite eccentric they may be linearly arranged in a narrow border at the proximal end and sides nearby. In the most rapidly gelatinized grains, the reaction generally progresses along the much-branched fissure through the mesial region and into the distal border, a narrow band of lamellæ at the junction of this border and main body of the grain as well as the outermost lamella of the border being disorganized into linear granules which are very resistant. In many grains the reaction is more rapid in the distal or entire marginal border; this border then becomes much swollen but not usually distorted, the outermost layer being broken into a linear row of granules, and as gelatinization proceeds this border may be ruptured at one or more points, often the latter, and then slashed quite deeply towards the center of the grain. Gelatinization in some of the elongated grains begins in a narrow area at the distal margin and advances gradually along a much-branched fissure towards the proximal end.

The gelatinized grains are much swollen and slightly to considerably distorted, many having no resemblance to the untreated grain. Refractive granules frequently remain in an otherwise completely gelatinized grain, and not infrequently the capsule may be quite deeply slashed as described above.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 33 per cent of the entire number of grains and 45 per cent of the total starch in 5 minutes; in about 87 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 96 per cent of the grains and in more than 99 per cent of the total starch in 30 minutes. (Chart D 49.)

The reaction with *hydrochloric acid* begins in a few grains immediately. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 8 per cent of the grains and 40 per cent of the total starch in 15 minutes; in about 25 per cent of the grains and 62 per cent of the total starch in 30 minutes; in about 46 per cent of the grains and 75 per cent of the total starch in 45 minutes; in about 60 per cent of the grains and 86 per cent of the total starch in 60 minutes. (Chart D 48.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 9 per cent of the entire number of grains and 14 per cent of the total starch in 5 minutes; in about 15 per cent of the grains and 50 per cent of the total starch in 15 minutes; in about 30 per cent of the grains and 62 per cent of the total starch in 30 minutes; in about 35 per cent of the grains and 69 per cent of the total starch in 45 minutes; in about 47 per cent of the grains and 73 per cent of the total starch in 60 minutes. (Chart D 49.)

The reaction with *potassium iodide* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 7 per cent of the grains and 11 per cent of the total starch in 15 minutes; in about 15 per cent of the grains and 19 per cent of the total starch in 30 minutes; in about 16 per cent of the grains and 21 per cent of the total starch in 45 minutes; in about 19 per cent of the grains and 23 per cent of the total starch in 60 minutes. (Chart D 50.)

The hilum swells slightly but no bubble was detected at this region; the hilum is occasionally fissured and the clefts then become enlarged and more refractive. The entire grain appears to be very refractive, but in a small number of grains a few lamellæ may grow more distinct, notably one which forms a demarcation between the main body and a slightly more refractive border. Very refractive grains without any especially refractive border may exhibit punctation previous to gelatinization. Deep fissures which are varied in character having a relation to the shape of the grain are present in the untreated grain or are quickly formed, and numerous delicate fissures branching from these main fissures, or radiating from the hilum, appear. Gelatinization is varied in character; in the most quickly gelatinized grains the reaction advances distalwards from the hilum through the mesial region, the lamellæ being disorganized into a mass of very refractive granules until a narrow marginal band of deeply striated starch is reached; this band is disorganized into linearly arranged granules. In more resistant grains the lamellæ of the refractive border become sharply defined, followed by rapid gelatinization and distortion, frequently without the appearance of granules. In many grains the reaction begins at the distal margin and advances towards the proximal end, while in others it may advance from both ends towards a centric or nearly centric hilum. The most resistant area in the majority of grains is a narrow very refractive border at the proximal end and sides nearby.

The gelatinized grains are swollen and slightly to much distorted so that they do not usually resemble the shape of the untreated grain. A few to many refractive granules are often present and these are more numerous in a border just above the distal margin and at the proximal end and sides nearby. At the end of the reaction many grains are little if at all affected beyond the swelling of the hilum.

The reaction with *potassium sulphocyanate* begins in a few grains in half a minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 10 per cent of the total starch in 15 minutes; in about 28 per cent of the grains and 34 per cent of the total starch in 30 minutes; in about 36 per cent of the grains and 48 per cent of the total starch in 45 minutes; in about 50 per cent of the grains and 64 per cent of the total starch in 60 minutes. (Chart D 51.)

The hilum enlarges and becomes very distinct, and though a fissure is often not present in the untreated grain, one soon forms. The fissure is usually a transverse, oblique, or longitudinal line with irregular branches which at times divide the central portion of the grain into irregularly shaped granules. The lamellæ gradually become very distinct and in some grains remain so, but in others are obscured by striæ radiating from the hilum. Gelatinization begins at the hilum and is preceded by the enlargement of the hilum and the formation of fissures and granules already described, and by the formation of

distinct, rather fine striæ from the hilum to the margin. In the majority of the grains fissuration also extends from the hilum to the distal margin (if the hilum is eccentric), or to some portion of the margin if it is centric, and divides this segment of the grain into many fine granules. Gelatinization in the majority of the grains proceeds from this beginning, first distalward, the granular material being moderately rapidly gelatinized, while the more resistant material at the proximal end is pushed to the margin and there forms a striated, lamellated band which becomes transformed into rows of granules as gelatinization progresses; these granules in turn are gradually gelatinized. In other grains gelatinization proceeds at first equally in all directions from the hilum, but even here it may be seen later to advance more rapidly in one direction than in others. The gelatinized grains have granules ranged just inside the capsule, persisting after the rest of the material is gelatinized.

The gelatinized grains are large and usually considerably distorted, but retain some resemblance to the untreated grain.

The reaction with *potassium sulphide* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 4 per cent of the total starch in 45 minutes; little if any further change in 60 minutes. (Chart D 52.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 12 per cent of the grains and 31 per cent of the total starch in 15 minutes; in about 25 per cent of the grains and 39 per cent of the total starch in 30 minutes; in about 28 per cent of the grains and 44 per cent of the total starch in 45 minutes; in about 34 per cent of the grain and 48 per cent of the total starch in 60 minutes. (Chart D 53.)

The reaction with *sodium sulphide* begins in a few grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 0.5 per cent of the grains and 3 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 5 per cent of the total starch in 30 minutes; in about 5 per cent of the grains and 8 per cent of the total starch in 45 minutes; in about 6 per cent of the grains and 9 per cent of the total starch in 60 minutes. (Chart D 54.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 38 per cent of the entire number of grains and 45 per cent of the total starch in 5 minutes; in about 88 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 98 per cent of the grains and in more than 99 per cent of the total starch in 30 minutes; in more than 99 per cent of both the grains and total starch in 45 minutes. (Chart D 55.) A small bubble which does not expand very much appears at the hilum and occasionally the hilum is fissured and the clefts then become more enlarged and refractive. The lamellæ do not, as a rule, become any more distinct than in the untreated grain. A refractive border forms around the grain or only at the distal margin. Gelatinization may begin in any prominent corner, but in the majority of grains it starts almost simultaneously from two ends and advances towards a centric or slightly eccentric hilum; as the bubble is expelled a fissure furrows through the area surrounding the hilum, leaving a narrow band of starch at either side of this region which gradually becomes gelatinized. In grains with a quite eccentric hilum, the process starts at the distal margin and advances towards the proximal end, a narrow band at this end and the sides nearby proving the most resistant starch. The gelatinized grains are swollen and distorted so that they do not resemble the untreated grain.

The reaction with *calcium nitrate* begins in rare grains in half a minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes. (Chart D 56.)

The reaction with *uranium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 6 per cent of the total starch in 30 minutes; in about 6 per cent of the grains and 9 per cent of the total starch in 45 minutes; in about 8 per cent of the grains and 10 per cent of the total starch in 60 minutes. (Chart D 57.)

The reaction with *strontium nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 7 per cent of the total starch in 15 minutes; in about 6 per cent of the grains and 10 per cent of the total starch in 30 minutes; in about 7 per cent of the grains and 11 per cent of the total starch in 45 minutes; in about 9 per cent of the grains and 12 per cent of the total starch in 60 minutes. (Chart D 58.)

The reaction with *cobalt nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; still in less than 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 30 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 59.)

The reaction with *copper nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 30 minutes; in about 3 per cent of the grains and 4 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 5 per cent of the total starch in 60 minutes. (Chart D 60.) Gelatinization more frequently follows the course of deep fissures through the mesial portion of the grain, but in elongated

grains may begin at the distal end, accompanied by distention of the capsule at this region.

The reaction with *cupric chloride* begins in very rare grains in 1 minute. Complete gelatinization occurs in much less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 30 minutes; in about 3 per cent of the grains and 4 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 61.)

The reaction with *barium chloride* begins in very rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; still in less than 0.5 per cent of the grains and total starch in 15 minutes; still in less than 0.5 per cent of the grains and 1 per cent of the total starch in 30 minutes; in about 0.5 per cent of the grains and 2 per cent of the total starch in 45 minutes; in about 1 per cent of the grains and 3 per cent of the total starch in 60 minutes. (Chart D 62.)

The reaction with *mercuric chloride* begins in very rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; little if any progress in 15 minutes; slight progress, or about 1 per cent of the total starch in 30 minutes; complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 45 minutes; little if any further progress in 60 minutes. (Chart D 63.)

Hippeastrum pyrrha (Pollen Parent).

(Plate 2, fig. 11; Charts D 43 to D 63.)

Histologic Properties.

In *form* the grains are usually simple and isolated, and there are fewer compound grains consisting usually of two, rarely more, components, and fewer aggregates than were recorded in *H. ossultan;* many more single grains, however, are noted with one or more pressure facets on the distal end or on the sides. This starch is somewhat more irregular than that of *H. ossultan.* The irregularities are due to the following causes: (1) Shallow depressions in and flattening of the margin; (2) secondary deposits on the primary grain; (3) a few nipple-like protuberances; (4) the greater development of one part of the distal margin, or of one side; (5) pressure facets on the distal end and sides. The conspicuous forms are round and nearly round, elliptical and ovoid, usually with both ends rounded. There are also lenticular, reniform, and triangular forms. This starch closely resembles *H. ossultan* in form, the most conspicuous difference being in its tendency to more irregularity.

The *hilum* when not fissured is a moderately distinct, round or, rarely, lenticular-shaped spot. It is frequently fissured, much more often than was noted under *H. ossultan,* and the fissuration is more extensive. The fissures take the following forms: (1) A single, straight, transverse or oblique form; (2) cruciform, T- and Y-shaped; (3) flying-bird form; (4) a number of irregular fissures proceeding from a central cavity. The hilum is rarely centric, otherwise it is eccentric from 0.4 to 0.25, usually 0.3, of the longitudinal axis. The hilum is, as a rule, more eccentric than in *H. ossultan.*

The *lamellæ* are often indistinct, but there are more grains with distinct lamellæ than is noted in *H. ossultan.* They are rather coarse and usually all have the form of the outline of the grain though this may be considerably modified. When there are secondary deposits of the starch the lamellæ are coarser and more distinct in these than in those of the primary deposit. The number of lamellæ counted on some of the common-sized and larger grains varies from 6 to 12, usually 8. There are fewer lamellæ on the grains, as a rule, than in *H. ossultan.*

In *size* the grains vary from the smaller which are 3 by 3μ to the larger broad forms which are 34 by 32μ and the larger elongated forms which are 38 by 30μ in length and breadth. The common-sizes are 20 by 20μ, and 20 by 16μ. The grains are smaller than those of *H. ossultan,* but have, as a rule, much the same proportions of length to breadth.

Polariscopic Properties.

The *figure* varies from centric to eccentric, the majority being eccentric, hence the mean is eccentric—slightly more eccentric than in *H. ossultan.* The figure is usually distinct and clean-cut. The lines vary from fine to moderately coarse with broadening towards the margin as in *H. ossultan,* and most of them intersect obliquely, though some cross at right angles, while rarely they are so arranged as to form a median line with bisected ends, the last two a little less frequently than in *H. ossultan.* The lines are usually straight, but are occasionally bent, a little less frequently than in *H. ossultan.* Double figures are occasionally present, but less frequent than in *H. ossultan.*

The *degree of polarization* is moderately high to very high (value 85), a little less of the former than in *H. ossultan,* hence the mean is slightly higher; variation also occurs in the same aspect of a given grain as in *H. ossultan.*

With *selenite* the quadrants are well defined, generally unequal in size, and usually regular in shape, about the same as in *H. ossultan.* The colors are generally pure, about the same as in *H. ossultan.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains immediately color a moderate to moderately deep blue-violet (value 55), deeper and more bluish in tint than in *H. ossultan,* and the color deepens quickly to deep, deeper than in *H. ossultan.* With 0.125 per cent Lugol's solution the grains color light to moderately light blue-violet, a little deeper than in *H. ossultan,* which quickly deepens from moderately deep to deep. After heating in water until the grains are gelatinized, and then adding a 2 per cent Lugol's solution the *grains* color a light to deep blue, many with a reddish tint, the mean moderately deep in color, deeper and less reddish in tint than in *H. ossultan,* and the *solution* a deep indigo-blue. If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution the *grain-residues* color a light to deep blue, occasionally tinged with red, the mean is moderately light to moderate in depth, lighter and less reddish in tint than in *H. ossultan.* The *capsules* color a light violet to moderate heliotrope, the mean being moderately light, lighter and less reddish in tint than in *H. ossultan;* and the *solution* colors a very deep indigo-blue.

Aniline Reactions.

With *gentian violet* the grains immediately stain very lightly, a little lighter than in *H. ossultan*, and in half an hour they become moderately light to moderate in color (value 48), lighter and with more variation in depth of the individual grains than in *H. ossultan*.

With *safranin* the grains immediately stain very lightly, a little lighter than in *H. ossultan*, and in half an hour they stain from light to moderately deep, the mean being moderate (value 50), and there is a greater variation in the depth of the individual grains with the mean lighter than in *H. ossultan*.

Temperature Reactions.

The majority of the grains are gelatinized at 71° to 73° C. and of all but very rare grains at 73° to 74° C., mean 73.5° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 16 per cent of the grains and 19 per cent of the total starch in 15 minutes; in about 25 per cent of the grains and 28 per cent of the total starch in 30 minutes; in about 37 per cent of the grains and 39 per cent of the total starch in 45 minutes; in about 41 per cent of the grains and 42 per cent of the total starch in 60 minutes. (Chart D 43.)

One or more bubbles, more frequently the former, may appear at the hilum; the bubble may expand to considerable size, in some grains more than in *H. ossultan*; and a cleft which is present at the hilum in a number of untreated grains becomes much enlarged and refractive, and is more frequently observed than in *H. ossultan*. The lamellæ do not become more distinct; but the entire grain is more refractive and a border of slightly greater refractivity appears around the main body of the grain as in *H. ossultan*. A delicate fissure may proceed from or intersect the hilum, which becomes deeper and branched as the reaction proceeds, and this is a little more prominent than in *H. ossultan*. Gelatinization begins and proceeds according to the methods described in *H. ossultan*, but the reaction much more frequently begins at the distal margin and proceeds towards the proximal end than in that species. The starch is disorganized into refractive granules that are a little more resistant than in *H. ossultan*.

The gelatinized grains are swollen and considerably distorted so that they do not resemble the form of the untreated grain, about the same as in *H. ossultan*.

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; still in less than 0.5 per cent of the grains and 20 per cent of the total starch in 15 minutes; in about 50 per cent of the grains and 75 per cent of the total starch in 20 minutes; in about 62 per cent of the grains and 90 per cent of the total starch in 25 minutes; in more than 99 per cent of the grains and total starch in 30 minutes. (Chart D 44.)

The reaction with *pyrogallic acid* begins in a few grains in 1 minute. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 36 per cent of the grains and 80 per cent of the total starch in 15 minutes; in about 78 per cent of the grains and 89 per cent of the total starch in 30 minutes; in about 84 per cent of the grains and 92 per cent of the total starch in 45 minutes; in about 90 per cent of the grains and 96 per cent of the total starch in 60 minutes. (Chart D 45.)

The reaction with *nitric acid* begins in a few grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 6 per cent of the total starch in 15 minutes; in about 10 per cent of the grains and 16 per cent of the total starch in 30 minutes; in about 15 per cent of the grains and 33 per cent of the total starch in 45 minutes; in about 17 per cent of the grains and 50 per cent of the total starch in 60 minutes. (Chart D 46.)

The hilum swells and a bubble is somewhat more frequently observed than in *H. ossultan*. The fissures present in the untreated grain become enlarged and more refractive, more frequent and refractive than in *H. ossultan*, and the refractivity is gradually lost without the apparent expulsion of a bubble. The grain becomes refractive throughout its entire extent and occasionally a few lamellæ become more distinct, but they are little more frequently demonstrable than in *H. ossultan*. A border which is but slightly more refractive than the main body of the grain is quite common and may be separated from the main body of the grain by a distinct clear lamella as in *H. osultan*. Either one or two fissures appear according to the shape of the grain; more frequently one is present, which either proceeds distally from the hilum or may intersect this point; and the fissures are much deeper and more profusely branched than in *H. ossultan*. The progress of the reaction is much varied and the disorganization of the lamellæ is generally accompanied by the appearance of large refractive granules, which have the same arrangement but are more resistant than in *H. ossultan*.

The gelatinized grains are much swollen and slightly to considerably distorted so that they do not usually resemble the untreated grain as in *H. ossultan*. A few grains are found which contain no refractive granules, less than in *H. ossultan*. Fewer grains undergo complete gelatinization, but a large number are partially gelatinized and hence the difference between complete and total gelatinization is greater than in *H. ossultan*. The capsule of the gelatinized grains is less frequently slashed in one or more places than in *H. ossultan*.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 45 per cent of the entire number of grains and 70 per cent of the total starch in 5 minutes; in about 90 per cent of the grains and 96 per cent of the total starch in 15 minutes; in about 98 per cent of the grains and more than 99 per cent of the total starch in 30 minutes. (Chart D 47.)

The reaction with *hydrochloric acid* begins in a few grains immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 11 per cent of the grains and 41 per cent of the total starch in 15 minutes; in about 33 per cent of the grains and 70 per cent of the total starch in 30 minutes; in about 50 per cent of the grains and 80 per cent of the total starch

in 45 minutes; in about 62 per cent of the grains and 88 per cent of the total starch in 60 minutes. (Chart D 48.)

The reaction with *potassium hydroxide* begins in a few grains immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 8 per cent of the total starch in 5 minutes; in about 16 per cent of the grains and 51 per cent of the total starch in 15 minutes; in about 37 per cent of the grains and 72 per cent of the total starch in 30 minutes; in about 45 per cent of the grains and 74 per cent of the total starch in 45 minutes; in about 50 per cent of the grains and 75 per cent of the total starch in 60 minutes. (Chart D 49.)

The reaction with *potassium iodide* begins in a few grains immediately. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 0.5 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 7 per cent of the total starch in 30 minutes; in about 5 per cent of the grains and 11 per cent of the total starch in 45 minutes; in about 12 per cent of the grains and 17 per cent of the total starch in 60 minutes. (Chart D 50.)

The hilum swells slightly and occasionally a small bubble may be detected; the hilum is sometimes fissured and the clefts become enlarged and very refractive; the bubble and fissures are more frequent and the latter more prominent than in *H. ossultan.* The entire grain becomes more refractive and occasionally a few lamellæ become more distinct, notably one which forms a demarcation between the main body and a border of slightly greater refractivity; the definition of the lamellæ is slightly less frequent and the refractive border a little less prominent than in *H. ossultan.* The formation of the fissures and the disorganization of the lamellæ into refractive granules are similar, but the fissures are a little deeper and the granules a little more resistant than in *H. ossultan.* The methods of gelatinization are varied as in *H. ossultan,* but the gelatinization of the refractive border is accompanied by less distortion and the reaction more frequently begins at the distal margin and advances to the proximal end than in *H. ossultan.* The most resistant area in a larger number of grains is a narrow border at the proximal end and sides nearby.

The gelatinized grains are swollen and slightly to much distorted, a little less than in *H. ossultan.* Many grains are found which contain refractive granules, more than in *H. ossultan.* A large number of grains are little if any affected by the reagent beyond the initial steps, more than in *H. ossultan.*

The reaction with *potassium sulphocyanate* begins in a few grains in half a minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 12 per cent of the grains and 25 per cent of the total starch in 30 minutes; in about 33 per cent of the grains and 46 per cent of the total starch in 45 minutes; in about 44 per cent of the grains and 61 per cent of the total starch in 60 minutes. (Chart D 51.) The hilum as in *H. ossultan* enlarges and becomes very distinct, and no bubble is found there, and if fissures are present in the untreated grain, as they frequently are, they become larger, and if not present they are quickly formed. They are similar to those found in *H. ossultan* except that they are more irregular and more branched. The lamellæ gradually become very distinct, but in most of the grains are obscured by the striæ which radiate from the hilum before gelatinization begins. Gelatinization always begins at the hilum as in *H. ossultan,* but sometimes also at the distal margin which is not noted in *H. ossultan.* Many deep cracks or fissures invade the grain and divide the starch into granules; in lenticular-shaped grains gelatinization may begin at the hilum and at either end. The progress of gelatinization is very similar to that in *H. ossultan,* except in the before-mentioned grains in which gelatinization begins at the margin as well as at the hilum, the two reactions rapidly approach one another, preceded by fissuring and granulation, and leaving the more resistant proximal material till later. There are found a much less number of grains than in *H. ossultan* in which a segment is fissured and gelatinized before the rest. In the majority of the grains gelatinization proceeds, at first, equally in all directions from the hilum, and later more rapidly distally than proximally. The gelatinized grains are large and considerably distorted but retain some of the form of the untreated grain. The gelatinized grains of *H. ossultan* and *H. pyrrha* have the same appearance.

The reaction with *potassium sulphide* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the grains and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; about the same percentage of the grains and 3 per cent of the total starch in 30 minutes; little if any further progress in 45 and 60 minutes. (Chart D 52.)

The reaction with *sodium hydroxide* begins in a few grains in half a minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 8 per cent of the total starch in 15 minutes; in about 13 per cent of the grains and 29 per cent of the total starch in 30 minutes; in about 22 per cent of the grains and 36 per cent of the total starch in 45 minutes; in about 24 per cent of the grains and 43 per cent of the total starch in 60 minutes. (Chart D 53.)

The reaction with *sodium sulphide* begins in a few grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes. (Chart D 54.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 26 per cent of the entire number of grains and 32 per cent of the total starch in 5 minutes; in about 87 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 96 per cent of the grains and 99 per cent of the total starch in 30 minutes; in about 98 per cent of the grains and more than 99 per cent of the total starch in 45 minutes. (Chart D 55.) A small bubble appears at the hilum which expands about as in *H. ossultan;* the hilum may be fissured, the clefts then becoming more enlarged and refractive, more frequently and more prom-

inent than in *H. ossultan.* The lamellæ become more sharply defined in some grains, more frequently than in *H. ossultan.* A refractive border forms either around the entire grain or at the distal margin, and may become quite broad previous to gelatinization; this border is more prominent than in *H. ossultan.* Gelatinization begins and proceeds as in *H. ossultan,* but in the majority of grains it starts from the distal margin and proceeds towards the proximal end; the most resistant starch being located in a narrow band at the proximal end and sides nearby, as noted in this method in *H. ossultan.* A fissure proceeding from or intersecting the hilum is more frequently observed in the earlier stages of the process than in *H. ossultan.* The gelatinized grains are swollen and distorted so that they do not resemble the untreated grain as in *H. ossultan.*

The reaction with *calcium nitrate* begins in rare grains in half a minute. Complete gelatinization occurs in 0.5 per cent of the grains and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes. (Chart D 56.)

The reaction with *uranium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 4 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes. (Chart D 57.)

The reaction with *strontium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 30 minutes; in about 4 per cent of the grains and 8 per cent of the total starch in 45 minutes; in about 8 per cent of the grains and 12 per cent of the total starch in 60 minutes. (Chart D 58.)

The reaction with *cobalt nitrate* begins in very rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; very slight progress in 30 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 59.)

The reaction with *copper nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; slight progress in 15, 30, 45, and 60 minutes, respectively (chart D 60), until at the completion of this period complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch.

The process is observed in but few grains, gelatinization proceeding along well-defined fissures through the mesial region of some grains, but in the elongated type may begin at the distal end accompanied by distention of the capsule, as in *H. ossultan.*

The reaction with *cupric chloride* begins in very rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; very slight progress in 15 minutes; still in less than 0.5 per cent of the grains and total starch in 30 minutes; slight progress in 45 minutes; in about 0.5 per cent of the grains and 2 per cent of the total starch in 60 minutes. (Chart D 61.)

The reaction with *barium chloride* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; still in less than 0.5 per cent of the grains and total starch in 15 minutes; little if any further advance in 30, 45, and 60 minutes, respectively. (Chart D 62.)

The reaction with *mercuric chloride* begins in very rare grains in 1 minute. Complete gelatinization was not observed in any grain and the progress has begun in but rare grains in 5 minutes; slight progress in 15, 30, 45, and 60 minutes; at the end of which period complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch. (Chart D 63.)

Hippeastrum ossultan-pyrrha (Hybrid).

(Plate 2, fig. 12; Charts D 43 to D 63.)

Histologic Properties

In *form* the grains are usually simple and isolated, but compound grains and aggregates are seen in about the same proportion as noted under *H. ossultan,* though more simple grains with pressure facets on the distal ends and sides are noted than in the starch of this parent. The grains are more irregular than in those of either parent, in this respect more closely resembling *H. pyrrha.* The irregularities are due to the following causes: (1) Shallow and deep depressions in the margins; (2) pressure facets and other flattened places on the margin; (3) secondary deposits of starch whose longitudinal axes are at varying angles to those of the primary grain. The conspicuous forms are nearly round, round, elliptical, and ovoid. There are also dome-shaped, plano-convex, triangular, and lenticular forms. The grains in form more closely resemble those of *H. pyrrha* than of *H. ossultan,* though the starches of the parents and the hybrid resemble one another very closely.

The *hilum* when not fissured appears as a moderately distinct, round or lenticular spot; but it is usually fissured more often than in either parent, and the fissures have the following forms: (1) Cruciform, T-, or Y-shaped; (2) a single line which may be straight or curved, transverse or oblique, and occasionally having many small fissures branching from it. The hilum is, rarely, centric, more frequently eccentric from 0.44 to 0.25, usually 0.33, of the longitudinal axis. In the extent of the fissuration and in the range of eccentricity of the hilum, *H. ossultan-pyrrha* is nearer to *H. pyrrha* than to *H. ossultan.*

The *lamellæ* are often distinct, about as often as noted under *H. pyrrha,* and are similar in form and arrangement to those of that starch. The number counted on the common-size and larger grains varies from 8 to 18, usually about 12. In the character of the lamellæ *H. ossultan-pyrrha* is nearer to *H. pyrrha* than to *H. ossultan,* but the number is nearer *H. ossultan.*

The *size* of the grains varies from the smaller which are 3 by 3μ, to the larger broad forms which are 52 by 46μ, and the larger elongated forms which are 48 by 38μ or, rarely, 70 by 50μ in length and breadth. The common forms are 26 by 26μ, and 28 by 24μ. In size *H. ossultan-pyrrha* more closely resembles *H. ossultan* than *H. pyrrha*.

Polariscopic Properties.

The *figure* varies from centric to very eccentric as in the parents, the mean is slightly more eccentric than in *H. ossultan*, but slightly less than in *H. pyrrha*, and nearer to the latter. The lines vary from fine to moderately coarse with broadening at the margin as in both parents; and they usually intersect obliquely though they more frequently cross at right angles than in the parents. The arrangement of a median line with bisected ends is as frequent as in *H. ossultan*, but the last two occur a little more frequently than in *H. pyrrha*. The lines are more frequently straight, but bending and bisection are somewhat more frequent than in the parents, but a little closer to *H. ossultan*. Double figures are moderately frequent, as in *H. ossultan*, more numerous than in *H. pyrrha*, and less numerous than in *H. ossultan*.

The *degree of polarization* is high to very high (value 87). The same range of variation in the individual grains as well as in the same aspect of a given grain occurs as in the parents; but a larger proportion of grains with very high polarization are present and hence the mean is higher than in the parents, but nearer to *H. pyrrha*.

With *selenite* the quadrants are generally well defined, but the definition is somewhat less sharp in more grains than in the parents. The quadrants are generally unequal in size and regular in shape, though less frequently in the parents. The colors are generally pure, about the same degree of purity as in the parents.

In the degree of polarization, *H. ossultan-pyrrha* is closer to *H. pyrrha* than to *H. ossultan*, but in the character of the figure and in the appearance with selenite it is closer to *H. ossultan* than to *H. pyrrha*. A character appearing in a parent is often accentuated in the hybrid.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains color a moderately light to moderately deep blue-violet, the mean is moderate in depth (value 50), a little deeper in color and the same tint as in *H. ossultan*, not quite so deep in color nor so bluish in tint as in *H. pyrrha*. The color deepens to moderately deep to deep, a little deeper than *H. ossultan* but not quite so deep as *H. pyrrha*. With 0.125 per cent Lugol's solution the grains immediately color a light to moderate blue-violet, a little deeper than in *H. ossultan*, the same as in *H. pyrrha;* the grains quickly deepen from moderate to deep, a little deeper than in *H. ossultan*, about the same as in *H. pyrrha*. After heating in water until the grains are gelatinized and then adding a 2 per cent Lugol's solution, the gelatinized *grains* color a very light to deep blue, rarely with a reddish tint, the mean is moderate, about the same but much less reddish in tint than in *H. ossultan*, a little lighter and less reddish than in *H. pyrrha*. The *solution* colors a deep indigo-blue, about the same as in both parents. If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* color a light to deep blue, often tinged with red, the mean is moderate, not quite so reddish but of the same depth as in *H. ossultan*, deeper and more reddish than in *H. pyrrha*. Most of the *capsules* color a light to deep amethyst, with a few moderate old-rose, the mean is moderately light to moderate, a little lighter and a little less reddish than in *H. ossultan;* but both deeper and more reddish than in *H. pyrrha*. Qualitatively and quantitatively the reactions with iodine show a closer resemblance to *H. ossultan* than to *H. pyrrha*, but both parents and hybrid resemble one another closely.

Aniline Reactions.

With *gentian violet* the grains stain lightly at once, a little deeper than in the parents, but closer to *H. ossultan*, and in half an hour they stain moderate to moderately deep (value 53), a little deeper than in the parents, but nearer to *H. ossultan*.

With *safranin* the grains immediately stain very lightly, a little lighter than in *H. ossultan* but about the same as in *H. pyrrha;* and in half an hour they stain moderate to moderately deep (value 58), a little deeper than in both parents, but nearer to *H. ossultan*.

The reactions with aniline dyes show a very close resemblance to *H. ossultan* than to *H. pyrrha*, both of the parents and the hybrid are very close to one another.

Temperature Reactions.

The majority of the grains are gelatinized at 70° to 72° C., and of all but very rare grains at 72° to 73°, mean 72.5° C.

The temperature of gelatinization is closer to *H. pyrrha* than to *H. ossultan*.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 24 per cent of the grains and 26 per cent of the total starch in 15 minutes; in about 34 per cent of the grains and 36 per cent of the total starch in 30 minutes; in about 35 per cent of the grains and 40 per cent of the total starch in 45 minutes; in about 36 per cent of the grains and 43 per cent of the total starch in 60 minutes. (Chart D 43.)

One or more bubbles, more frequently the former, appear at the hilum; the bubble expands to greater size in more grains and an enlarged refractive fissure is more frequent than in the parents, but nearer to *H. pyrrha* than to *H. ossultan*. The lamellæ do not become more distinct; the entire grain becomes more refractive and a marginal border of slightly greater refractivity is formed, as noted for the parents. The methods of gelatinization are similar to those observed in the parents. The pitted appearance of the starch beneath the capsule is observed over a larger area of the grain, as well as in a larger number of grains, than in the parents, but a little closer to *H. ossultan*. The fissures formed during the process are less prominent, and the refractive granules are less frequently observed than in the parents, but closer to *H. ossultan*.

The grains are swollen and slightly to considerably distorted, but less grains with considerable distortion than in the parents.

In the reaction with chloral hydrate *H. ossultan-pyrrha* shows qualitatively a very close relationship to the parents, but is slightly closer to *H. ossultan* than to *H. pyrrha*. A character appearing in a parent is sometimes further developed in the hybrid.

The reaction with *chromic acid* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 45 per cent of the total starch in 15 minutes; in about 43 per cent of the grains and 86 per cent of the total starch in 20 minutes; in about 72 per cent of the grains and 96 per cent of the total starch in 25 minutes; in about 99 per cent of the grains and more than 99 per cent of the total starch in 30 minutes. (Chart D 44.)

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 18 per cent of the entire number of grains and 20 per cent of the total starch in 5 minutes; in about 60 per cent of the grains and 85 per cent of the total starch in 15 minutes; in about 88 per cent of the grains and 93 per cent of the total starch in 30 minutes; in about 92 per cent of the grains and 96 per cent of the total starch in 45 minutes; in about 95 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 41.)

The reaction with *nitric acid* begins in a few grains in half a minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 19 per cent of the total starch in 15 minutes; in about 16 per cent of the grains and 40 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 65 per cent of the total starch in 45 minutes; in about 22 per cent of the grains and 67 per cent of the total starch in 60 minutes. (Chart D 46.)

The hilum swells but no bubble was detected, about as in *H. ossultan*, a little less frequently than in *H. pyrrha;* and the fissures in the untreated grain become more refractive than in the parents, but nearer to *H. pyrrha*. The entire grain becomes very refractive, but the lamellæ occasionally become more distinct over the main body of the grain, more frequently than in the parents, but nearer that observed in *H. pyrrha* than in *H. ossultan*. One lamella forms a line of demarcation between the main body and the border in more grains than in the parents. The fissures are very deep and much branched, much more prominent than in *H. ossultan* and the same as in *H. pyrrha*. The method of gelatinization is varied as in both parents; and the lamellæ are disorganized with the appearance of very refractive granules, more refractive than in *H. ossultan* and the same as in *H. pyrrha*. The border, which may be either located only at the distal margin or surround the entire grain, is more frequently gelatinized before the main body of the grain and is accompanied by more distortion than in the parents, but nearer to *H. ossultan*. The rupture of the capsule at several points with deep slashing is not so frequent as in the parents, but nearer to *H. pyrrha*.

The gelatinized grains are swollen and slightly to considerably distorted, about as in the parents. A smaller number of grains are completely gelatinized but many more are deeply fissured and partially gelatinized than in *H. ossultan*, so that there is much greater variation between complete and total gelatinization than in that parent and in *H. pyrrha*.

In the reaction with nitric acid *H. ossultan-pyrrha* shows qualitatively a close resemblance to both parents, but is somewhat nearer to *H. pyrrha* than to *H. ossultan*. A character inherited from one or both parents may be accentuated or lessened in the hybrid.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 30 per cent of the entire number of grains and 40 per cent of the total starch in 5 minutes; in about 90 per cent of the grains and 95 per cent of the total starch in 15 minutes; in more than 99 per cent of the complete and total starch in 30 minutes. (Chart D 47.)

The reaction with *hydrochloric acid* begins in a few grains immediately. Complete gelatinization occurs in about 4 per cent of the grains and 6 per cent of the total starch in 5 minutes; in about 9 per cent of the grains and 50 per cent of the total starch in 15 minutes; in about 42 per cent of the grains and 82 per cent of the total starch in 30 minutes; in about 54 per cent of the grains and 89 per cent of the total starch in 45 minutes; in about 67 per cent of the grains and 91 per cent of the total starch in 60 minutes. (Chart D 48.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 10 per cent of the entire number of grains and 20 per cent of the total starch in 5 minutes; in about 20 per cent of the grains and 54 per cent of the total starch in 15 minutes; in about 37 per cent of the grains and 74 per cent of the total starch in 30 minutes; in about 49 per cent of the grains and 76 per cent of the total starch in 45 minutes; in about 53 per cent of the grains and 78 per cent of the total starch in 60 minutes. (Chart D 49.)

The reaction with *potassium iodide* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 10 per cent of the total starch in 15 minutes; in about 13 per cent of the grains and 20 per cent of the total starch in 30 minutes; in about 17 per cent of the grains and 25 per cent of the total starch in 45 minutes; in about 19 per cent of the grains and 33 per cent of the total starch in 60 minutes. (Chart D 50.)

The hilum swells slightly but no bubble was detected thereat as in *H. ossultan*, less frequent than in *H. pyrrha*. The hilum is frequently fissured and these fissures become enlarged and refractive, more prominent than in the parents, but nearer to *H. pyrrha*. The entire grain becomes very refractive, but in a few grains the lamellæ may become more distinct and a border of slightly greater refractivity may be separated from the main body of the grain by one very distinct lamella. The sharper definition of the lamellæ and the presence of a refractive border is about as frequent as in *H. ossultan*, but slightly more so than in *H. pyrrha*. Very refractive grains may become punctated previous to gelatinization, more commonly observed than in the parents. Deep fissures of the same character are formed as noted in the parents, they are somewhat deeper than in *H. ossultan*, about as deep and branched as in *H. pyrrha*. The same methods

of gelatinization are observed as those noted for the parents. The process more frequently starts in the border either at one or several points following very deep striation than in the parents, but nearer to *H. ossultan*. In addition to the methods of gelatinization noted in the parents, a mass of interlacing fissures may follow the punctation or pitting of the grain and the lamellæ be quickly disorganized into very refractive granules. The lamellæ of all the grains are usually disorganized into refractive granules previous to gelatinization as in the parents. These granules are less resistant than in the parents, but nearer the resistancy of *H. ossultan*, the most resistant starch, however, being located as in the parents.

The gelatinized grains are swollen and slightly to considerably distorted, not as much distorted in so many grains as in *H. ossultan*, but more than in *H. pyrrha*. Refractive granules remain in a number of otherwise completely gelatinized grains; about the same as in *H. ossultan*, but less with refractive granules than in *H. pyrrha*. Many grains are but little affected beyond the swelling of the hilum, but gelatinization is further advanced in a larger percentage of grains than in the parents, but nearer to *H. ossultan*.

In this reaction *H. ossultan-pyrrha* shows qualitatively a very close relationship to both parents, but slightly nearer to *H. ossultan*. A character inherited from one parent is often developed further in the hybrid.

The reaction with *potassium sulphocyanate* begins in a few grains in half a minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 10 per cent of the total starch in 15 minutes; in about 23 per cent of the grains and 48 per cent of the total starch in 30 minutes; in about 35 per cent of the grains and 61 per cent of the total starch in 45 minutes; in about 50 per cent of the grains and 70 per cent of the total starch in 60 minutes. (Chart D 51.)

The hilum enlarges and becomes very distinct as in the parents, and the fissuring is nearly the same as in *H. ossultan*, except that the fissures are more branched, but not so branched nor so irregular as in *H. pyrrha*. The lamellæ gradually become very distinct and in some grains remain so, but in others are obscured as in *H. ossultan*. Gelatinization begins at the hilum as in *H. ossultan*, and never at both hilum and margin as in some grains of *H. pyrrha*. The progress of gelatinization is the same as in *H. ossultan*, except that there are not so many in which fissuration and granulation of one segment of the grain occur as in *H. ossultan*, but more than in *H. pyrrha*. The gelatinized grains have the same appearance as those of the parents.

In the reaction with potassium sulphocyanate *H. ossultan-pyrrha* shows qualitatively a closer relationship to *H. ossultan* than to *H. pyrrha*, but the reaction is very close qualitatively in both parents and in the hybrid.

The reaction with *potassium sulphide* begins in very rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and of total starch in 5 minutes; still less than 0.5 per cent of the grains and of total starch in 15 minutes; in about 1 per cent of the grains and 3 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes, respectively. (Chart D 52.)

The reaction with *sodium hydroxide* begins in a few grains in half a minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 10 per cent of the grains and 27 per cent of the total starch in 15 minutes; in about 23 per cent of the grains and 35 per cent of the total starch in 30 minutes; in about 27 per cent of the grains and 43 per cent of the total starch in 45 minutes; in about 32 per cent of the grains and 45 per cent of the total starch in 60 minutes. (Chart D 53.)

The reaction with *sodium sulphide* begins in a few grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 4 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 6 per cent of the total starch in 30 minutes; in about 5 per cent of the grains and 8 per cent of total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 54.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 18 per cent of the grains and 22 per cent of the total starch in 5 minutes; in about 82 per cent of the grains and 85 per cent of the total starch in 15 minutes; in about 96 per cent of the grains and 98 per cent of the total starch in 30 minutes; in more than 99 per cent of both the grains and total starch in 45 minutes. (Chart D 55.) A small bubble appears at the hilum which in many of the grains is not inclosed within a fissure; yet a cleft appears at the hilum more frequently and expands to greater size than in the parents; but more closely resembles *H. pyrrha*. The definition of the lamellæ and the refractivity of the border is a little greater in both cases than in *H. ossultan*, but about the same as in *H. pyrrha*. The method of gelatinization is varied as noted for the parents. The reaction proceeds from both ends in many grains, a little less frequently than in *H. ossultan*, but more frequently than in *H. pyrrha*. In many grains the following is observed: The bubble at the hilum is very resistant and expands to considerable size; when gelatinization has almost reached the area around the hilum, a tortuous fissure is formed which forces its way through this region, the lamellæ located here often being disorganized by the appearance of refractive granules. This method is similar to one observed in the parents but the steps are more prominent, the fissure more tortuous, and the appearance of refractive granules not observed in the parents. The fissures which appear previous to gelatinization occur a little more often than in *H. ossultan*, about the same as in *H. pyrrha*. The gelatinized grains are swollen and distorted so that they do not resemble the untreated grain, as in both parents.

In the reaction with sodium salicylate *H. ossultan-pyrrha* shows qualitatively a closer relationship to the parents, but is a little closer to *H. pyrrha* than to *H. ossultan*. A character inherited from one parent is often developed further in the hybrid.

The reaction with *calcium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in

less than 0.5 per cent of the entire number of grains and also total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes, respectively. (Chart D 56.)

The reaction with *uranium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 4 per cent of the total starch in 30 minutes; very slight advance in 45 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 60 minutes. (Chart D 57.)

The reaction with *strontium nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; slight advance in 15 minutes; in about 2 per cent of the grains and 4 per cent of the total starch in 30 minutes; in about 3 per cent of the grains and 6 per cent of the total starch in 45 minutes; in about 9 per cent of the grains and 11 per cent of the total starch in 60 minutes. (Chart D 58.)

The reaction with *cobalt nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and also of the total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; slight progress in 30 and 45 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 60 minutes. (Chart D 59.)

The reaction with *copper nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains, and of total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; little if any progress noted in 30, 45, and 60 minutes, respectively. (Chart D 60.) The process follows the same course as that noted for the parents.

The reaction with *cupric chloride* begins in very rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the grains and of total starch in 45 minutes; still in less than 0.5 per cent of the grains of total starch in 15 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 30 minutes; little if any progress in 45 and 60 minutes, respectively. (Chart D 61.)

The reaction with *barium chloride* begins in very rare grains in 1 minute. Complete gelatinization occurs in much less than 0.5 per cent of both the grains and total starch in 5 minutes; very little progress in 15, 30, 45, and 60 minutes, respectively. At the end of 60 minutes only very rare grains are completely gelatinized, still less than 0.5 per cent, and gelatinization occurs in about 0.5 per cent of the total starch. (Chart D 62.)

The reaction with *mercuric chloride* begins in very rare grains in 1 minute. Complete gelatinization occurs in much less than 0.5 per cent of the grains and of total starch in 5 minutes; slight progress in 15 and 30 minutes; still less than 0.5 per cent of the grains gelatinized and 1 per cent of the total starch in 45 minutes; little if any progress in 60 minutes. (Chart D 63.)

4. Starches of Hippeastrum dæones, H. zephyr, and H. dæones-zephyr.

Hippeastrum dæones (Seed Parent).

(Plate 3, fig. 13; Charts D 64 to D 84.)

Histologic Properties.

In *form* the grains are usually simple and isolated, with the exception of a moderate number of aggregates of usually 2, sometimes 3 or 4, grains linearly arranged. There is also, a number of compound grains of two types, the most common consists of two components, each of which has a hilum surrounded by several lamellæ and the 2 grains surrounded by one or two common secondary lamellæ. The other type shows 2 to 12 hila set close together and surrounded by 10 to 20 common secondary lamellæ. Long, narrow, root- or finger-like aggregates or compound grains are characteristic of this starch. The grains are often somewhat irregular in form and any irregularities are due to the following causes: (1) To nipple-like and finger-like protuberances from the proximal or distal ends or from the sides; (2) shallow notches and wide depressions in the margin at various points; (3) a secondary set of lamellæ whose longitudinal axis is at an angle with that of the primary set; (4) a deviation of the longitudinal axis of the primary lamellæ with a consequent bending of the grain at one end. The conspicuous forms are round, nearly round, broad and narrow ovoid, plano-convex, and lenticular. There are also triangular, long narrow elliptical, irregularly quadrilateral with rounded corners, and pyriform. They are not flattened.

The *hilum* is a distinct, moderately small, round or lenticular spot which is frequently hollowed out into a cavity and less frequently fissured. The fissuring takes the form of a small irregular Y or of a large irregularly branching, transverse, oblique, or longitudinal line. Often the hila of compound grains are separated by fissures which do not reach the margin of the grain. The hilum is sometimes centric, but is usually eccentric from 0.45 to 0.3, usually 0.38, of the longitudinal axis.

The *lamellæ* are moderately distinct, rather fine, continuous rings. Near the hilum they are circular or lenticular according to the form of the hilum; throughout the rest of the grain they are variable in form, only near the margin do they conform to the outline of the grain. The number of lamellæ counted on the common-sized and large grains varies from 10 to 25, usually 18.

The *size* of the smaller grains varies from 3 by 3μ to the larger broad forms which are 40 by 36μ or even 26 by 40μ in length and breadth, and the larger elongated forms which are 40 by 30μ in length and breadth. The common sizes are 26 by 16μ, 26 by 26μ, and 26 by 24μ.

Polariscopic Properties.

The *figure* varies from centric to very eccentric. The lines vary from fine to moderately coarse, more frequently the former, and while they intersect obliquely in the majority of the grains yet the intersection may be at right angles or may be arranged as a median line with bisected ends. The lines are usually straight with broadening at the margin, yet they may be either bent or bisected. Double and multiple figures are quite numerous.

The *degree of polarization* is high to very high (value 80) and varies in the different grains from moderately

high to very high, and frequently there is the same variation in the same aspect of a given grain.

With *selenite* the quadrants are usually well defined, mostly unequal in size, and more frequently regular in shape. The colors are commonly pure, the yellow is not quite so often pure as the blue.

Iodine Reactions.

With 0.25 Lugol's solution the grains color at once a moderate to a moderately deep blue-violet (value 55), the color deepens quickly from deep to very deep. With 0.125 Lugol's solution the grains color a light to moderate blue-violet, and the color deepens quickly, moderately deep to deep. After heating in water until the grains are gelatinized and then adding a 2 per cent Lugol's solution the *grains* color a light to very deep blue, many with a reddish tint, the mean is moderate to moderately deep. The *solution* becomes a deep indigo-blue; if the preparation is boiled for 2 minutes and then treated with a 2 per cent Lugol's solution the *grain-residues* color a light to deep blue, the mean moderately deep, some with a reddish tint; most of the *capsules* color a moderately deep to deep heliotrope and a few color a deep old-rose, the mean moderately deep to deep; and the *solution* colors a very deep indigo-blue.

Aniline Reactions.

With *gentian violet* the grains stain very lightly at once and in half an hour become moderate to moderately deep in color (value 58).

With *safranin* the grains color very lightly at once and in half an hour become moderate to moderately deep in color (value 55).

Temperature Reactions.

The majority of the grains are gelatinized at 72.5° to 74° C., and of all but very rare grains at 74° to 75° C., mean 74.5° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 1 minute. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 9 per cent of the total starch in 5 minutes; in about 27 per cent of the grains and 29 per cent of the total starch in 15 minutes; in about 39 per cent of the grains and 42 per cent of the total starch in 30 minutes; in about 47 per cent of the grains and 50 per cent of the total starch in 45 minutes; and about 53 per cent of the total starch in 60 minutes. (Chart D 64.)

One or more bubbles, more frequently one, appear at the hilum, and in some grains a fissure at the hilum becomes enlarged and more refractive. The lamellæ grow more distinct in a few grains. The entire grain appears more refractive and a border of slightly greater refractivity forms around the margin. The methods of gelatinization are as follows: A fissure may either proceed from or intersect the hilum and the process quickly advances through the mesial region along the course of such fissure, the most resistant part of the border being the starch located at the proximal end and sides nearby, one side frequently proving to be less resistant than the other. In some grains the entire surface, and in others one point of the border alone assumes a pitted appearance. Gelatinization of such grains is quite rapid and is accompanied by much swelling but less distortion of the capsule than when proceeding less rapidly from one center of gelatinization. Irregular fissures may form in the border, usually at the distal end, and disorganization into refractive fragments may precede gelatinization of this area; the process gradually advances toward the proximal end, the resistant starch being located as described above. In other grains the process starts at the distal end and is quickly followed at the proximal end, gelatinization then advancing from both points towards the hilar region; the bubble at the hilum is expelled as a fissure furrows through this area leaving a band of resistant starch on either side; this band becomes striated and broken into refractive granules previous to gelatinization. In the most resistant grains with markedly eccentric hilum, the process starts at the distal margin and advances towards the proximal end; in the least resistant of this type no definite fissure is noted near the distal margin, while in the most resistant a longitudinal fissure, which is quite deep and branched towards the extremities, disorganizes even the starch near the distal margin into refractive granules The gelatinized grains are swollen and slightly to considerably distorted, so that they do not usually resemble the form of the untreated grain.

The reaction with *chromic acid* begins in a very few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 60 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 84 per cent of the grains and 99 per cent of the total starch in 20 minutes; in about 100 per cent of both the grains and total starch in 25 minutes. (Chart D 65.)

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in about 13 per cent of the entire number of grains and 15 per cent of the total starch in 5 minutes; in about 50 per cent of the grains and 70 per cent of the total starch in 15 minutes; in about 82 per cent of the grains and 96 per cent of the total starch in 30 minutes; in about 90 per cent of the grains and 96 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 66.)

The reaction with *nitric acid* begins in a few grains in half a minute. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in about 29 per cent of the grains and 32 per cent of the total starch in 15 minutes; in about 40 per cent of the grains and 70 per cent of the total starch in 30 minutes; in about 50 per cent of the grains and 73 per cent of the total starch in 45 minutes; in about 52 per cent of the grains and 78 per cent of the total starch in 60 minutes. (Chart D 67.)

A small bubble appears at the hilum which usually expands very little and is quite persistent; a fissure that is sometimes present at the hilum in the untreated grain becomes enlarged and very refractive. The entire grain grows very refractive and the lamellæ do not usually appear more distinct, with the exception of one lamella which forms a line of demarcation between the main body of the grain and a border of slightly greater refractivity. One fissure often intersects the hilum, and somewhat less frequently 2 fissures may proceed distalwards

from the hilum; these fissures usually become very deep and often much branched. The gelatinization of the grains is varied in character, generally preceded by the appearance of very refractive granules and often followed by partial solution at the distal margin. In the grains with a quite eccentric hilum gelatinization starts at the distal margin and advances towards the proximal end, a narrow band at the proximal end and sides nearby proving the most resistant part of the grain. When the hilum is centric or but slightly eccentric, gelatinization is almost simultaneous from both ends and then advances towards the hilum, a narrow band for a short distance at either side of the hilum proving the most resistant part of the grain. Occasionally the reaction may start in the border and extend around the grain previous to the gelatinization of the main body of the grain; this border may either be considerably distorted, or the outermost lamella may be broken down into linearly arranged granules bounding a much swollen but undistorted border. In some grains the process proceeds along the course of sharply defined fissures through the mesial region which is quickly disorganized into a mass of very refractive granules, a very refractive and profusely striated border being the most resistant; this border is finally disorganized at the distal margin previous to the disorganization of the proximal end and sides nearby.

The gelatinized grains are swollen and slightly to much distorted so that they do not usually resemble the form of the untreated grain. Many grains are but partially gelatinized, a refractive band and also a mass of refractive granules proving very resistant. A number of grains are but little affected by the reagent at the end of 60 minutes.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 48 per cent of the grains and 95 per cent of the total starch in 5 minutes; in over 99 per cent of both the grains and total starch in 15 minutes; in 100 per cent of both the grains and total starch in 30 minutes. (Chart D 68.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 10 per cent of the entire number of grains and 12 per cent of the total starch in 5 minutes; in about 38 per cent of the grains and 75 per cent of the total starch in 15 minutes; in about 50 per cent of the grains and 83 per cent of the total starch in 30 minutes; in about 58 per cent of the grains and 90 per cent of the total starch in 45 minutes; in about 60 per cent of the grains and 92 per cent of the total starch in 60 minutes. (Chart D 69.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 13 per cent of the entire number of grains and 16 per cent of the total starch in 5 minutes; in about 41 per cent of the grains and 67 per cent of the total starch in 15 minutes; in about 60 per cent of the grains and 72 per cent of the total starch in 30 minutes; in about 61 per cent of the grains and 81 per cent of the total starch in 45 minutes; in about 67 per cent of the grains and 83 per cent of the total starch in 60 minutes. (Chart D 70.)

The reaction with *potassium iodide* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 12 per cent of the total starch in 15 minutes; in about 14 per cent of the grains and 29 per cent of the total starch in 30 minutes; in about 26 per cent of the grains and 38 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 45 per cent of the total starch in 60 minutes. (Chart D 71.)

The hilum swells slightly but a bubble is not formed and if fissures are located at this region in the untreated grain they become enlarged and more refractive. The entire grain grows more refractive but in some grains the lamellæ appear more distinct, especially one which forms a line of demarcation between the main body of the grain and a border of slightly greater refractivity than the main body of the grain. The fissures at the hilum become more prominent and numerous branches may proceed from them; 1 or 2 much-branched fissures may proceed distalwards from the hilum, and sometimes delicate fissures may radiate from the entire margin of the hilum. The gelatinization of the grains is varied in character. In the most quickly gelatinized grains, the reaction advances from the hilum distalwards through the mesial region; the lamellæ along this path are disorganized into a mass of refractive granules until a narrow, deeply striated band of starch is reached; this band being disorganized into linearly arranged very resistant refractive granules, and these granules are located either directly at the margin or just within a gelatinized border. In some grains this band of granules becomes gelatinized, those at the proximal end and sides nearby proving the most resistant; in others this band may be broken into small refractive segments followed by a dissolution of the capsule at several points and a slitting of the grain. Gelatinization of the grain is sometimes preceded by a deeply pitted condition followed by the appearance of numerous fissures and the rapid disorganization of the lamellæ into irregularly massed refractive granules. In grains with a quite eccentric hilum the reaction usually begins at the distal margin and advances towards the proximal end, while in grains with centric or slightly eccentric hilum the process may start almost simultaneously at both ends and advance towards the hilum.

The gelatinized grains are swollen and slightly to considerably distorted, so that they do not usually resemble the untreated grain. Refractive granules in otherwise gelatinized grains are often present, and many grains are but little affected at the end of 60 minutes beyond the swelling of the hilum.

The reaction with *potassium sulphocyanate* begins in a few grains in half a minute. Complete gelatinization occurs in about 7 per cent of the entire number of grains and 11 per cent of the total starch in 5 minutes; in about 26 per cent of the grains and 52 per cent of the total starch in 15 minutes; in about 50 per cent of the grains and 68 per cent of the total starch in 30 minutes; in about 58 per cent of the grains and 75 per cent of the total starch in 45 minutes; in about 63 per cent of the grains and 84 per cent of the total starch in 60 minutes. (Chart D 72.)

The hilum enlarges slightly and is very distinct, but no bubble is formed there, and, if the hilum is fissured in the untreated grain, the fissures become enlarged. In many of the grains, the lamellæ become at first gradually more distinct, and later are obscured by striæ radiating from the hilum. Fissures if not already present at the

hilum in the untreated grains are soon found, and usually consist of one (intersecting the hilum longitudinally) from which several extensive branches arise, and from these in turn many smaller branches. If the hilum is eccentric, as is often the case, this fissuration spreads out to the distal margin and so divides the substance of this segment of the grain into many fine granules. In the meantime the material at the sides and at the proximal end is divided by fine striæ which radiate from the hilum to the margin. The progress of gelatinization from this beginning is, first, distalward, the granular material being moderately rapidly gelatinized, while the more resistant material at the proximal end is pushed to the margin and there forms a broadly striated, lamellated band which becomes transformed into rows of granules as gelatinization progresses and the grain continues to enlarge, and these granules in turn are gradually gelatinized. Often, however, scattered granules remain in the gelatinized material for a long time after the rest of gelatinization is complete, and these are gradually gelatinized later. The gelatinized grains are much swollen and usually somewhat distorted, but retain some resemblance to the form of the untreated grain.

The reaction with *potassium sulphide* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 0.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 3 per cent of the total starch in 30 minutes; very slight progress in 45 minutes; in about 2 per cent of the grains and 4 per cent of the total starch in 60 minutes. (Chart D 73.)

The reaction with *sodium hydroxide* begins in a few grains in half a minute. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 7 per cent of the grains and 18 per cent of the total starch in 15 minutes; in about 20 per cent of the grains and 43 per cent of the total starch in 30 minutes; in about 33 per cent of the grains and 45 per cent of the total starch in 45 minutes; in about 37 per cent of the grains and 52 per cent of the total starch in 60 minutes. (Chart D 74.)

The reaction with *sodium sulphide* begins in a few grains in half a minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 7 per cent of the grains and 10 per cent of the total starch in 15 minutes; in about 10 per cent of the grains and 16 per cent of the total starch in 30 minutes; in about 19 per cent of the grains and 23 per cent of the total starch in 45 minutes; in about 22 per cent of the grains and 27 per cent of the total starch in 60 minutes. (Chart D 75.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 20 per cent of the entire number of grains and 25 per cent of the total starch in 5 minutes; in about 70 per cent of the grains and 76 per cent of the total starch in 15 minutes; in about 94 per cent of the grains and 96 per cent of the total starch in 30 minutes; in about 98 per cent of the grains and over 99 per cent of the total starch in 45 minutes. (Chart D 76.)

A small bubble appears at the hilum, which is more frequently not inclosed within a fissure. Very little expansion of the bubble previous to its expulsion occurs in the majority of grains, but when inclosed within a fissure considerable expansion is often observed, although not uncommonly a cleft already existent at the hilum in the untreated grain becomes enlarged and more refractive. The lamellæ do not usually become more sharply defined, and a refractive border forms around the main body of most of the grains. Fissures either proceeding from or intersecting the hilum sometimes form during the process of gelatinization; usually just previous to the expulsion of the bubble. Gelatinization begins at the margin of the grain. When the hilum is centric or but slightly eccentric the process starts almost simultaneously from both ends and then advances towards the hilum, a fissure ploughing its way through this area as the bubble at the hilum is expelled, a narrow band of starch on either side of the area surrounding the hilum proving the most resistant. When the hilum is quite eccentric gelatinization will begin at the distal margin and the process will then advance towards the proximal end, a narrow border of starch at the proximal end and sides nearby proving the most resistant When a grain has one or more prominent corners gelatinization often begins at these points; or if the grain is rounded a refractive border inclosing the main body of the grain may become gelatinized, and then proceed more quickly from one point through the rest of the grain.

The gelatinized grains are swollen and distorted so that they do not resemble the form of the untreated grain.

The reaction with *calcium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; slight progress in 30 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 45 minutes; in about 3 per cent of the grains and 4 per cent of the total starch in 60 minutes. (Chart D 77.)

The reaction with *uranium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 4 per cent of the total starch in 30 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 45 minutes; very little if any further advance in 60 minutes. (Chart D 78.)

The reaction with *strontium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 11 per cent of the total starch in 30 minutes; in about 8 per cent of the grains and 19 per cent of the total starch in 45 minutes; in about 14 per cent of the grains and 25 per cent of the total starch in 60 minutes. (Chart D 79.)

The reaction with *cobalt nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than

0.5 per cent of the entire number of grains and also in the total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; slight progress in 30 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 45 minutes; little if any further progress in 60 minutes. (Chart D 80.)

The reaction with *copper nitrate* begins in rare grains in half a minute. Complete gelatinization occurs in a few grains, less than 0.5 per cent of the entire number of grains, and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; slight progress in 30 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 4 per cent of the total starch in 60 minutes. (Chart D 81.) Gelatinization proceeds through the mesial region along the course of deep fissures, the reaction in elongated grains being more rapid at the distal margin.

The reaction with *cupric chloride* begins in very rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains as well as in the total starch in 5 minutes; still in less than 0.5 per cent of the grains and total starch in 15 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 30 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 45 minutes; little if any further progress in 60 minutes. (Chart D 82.) Gelatinization proceeds along the course of deep fissures from the hilum to the distal margin, the latter region being gelatinized previous to the proximal end and sides nearby.

The reaction with *barium chloride* begins in very rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains as well as in the total starch in 5 minutes; very slight progress in 15 minutes; still in less than 0.5 per cent of the grains and total starch in 30 minutes; very slight progress in 45 minutes; still in less than 0.5 per cent of the grains and 1 per cent of the total starch in 60 minutes. (Chart D 83.)

The reaction with *mercuric chloride* begins in very rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains as well as in the total starch in 5 minutes; still in less than 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; slight progress in 30 and 45 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 60 minutes. (Chart D 84.)

Hippeastrum zephyr (Pollen Parent).

(Plate 3, fig. 14; Charts D 64 to D 84.)

Histologic Properties.

In *form* the grains are usually simple and isolated, and there are less numbers of aggregates and of compound grains than in *H. dæones*. The grains have the same characteristics as those described under that parent, except that the long, narrow, root-like or finger-like grains noted in that starch are not seen in this. The grains are more regular in form than those of *H. dæones*, and any irregularities which occur are due to the same causes as have been described in those grains. It is to be noted, however, that protuberances from the distal and proximal ends and sides are less numerous and not so large as in that starch. The conspicuous forms are nearly round, round, long and slender ovoid, short broad ovoid with pointed ends, and elliptical. There are also triangular, plano-convex, and lenticular forms. The broad forms tend to be somewhat flattened, but the other forms are not. The grains are, as a rule, more rounded in form than those of *H. dæones*, but are very much like them.

The *hilum* is less distinct and less frequently fissured than in *H. dæones*. The fissures usually have the form of an irregularly branched transverse, oblique, or longitudinal line, and occasionally small irregular Y-shaped figures. The hilum is sometimes centric, but usually eccentric from 0.46 to 0.3, usually 0.4 of the longitudinal axis. The eccentricity of the hilum is the same as in *H. dæones*.

The *lamellæ* are less distinct and less fine than in *H. dæones*, but are otherwise similar in form and arrangement. The number counted on the common-sized and larger grains varies from 8 to 18, usually 14. There are fewer lamellæ on these grains than in *H. dæones*.

The *size* of the grains varies from the smaller which are 2 by 2μ, to the larger broad forms which are 38 by 36μ, and the larger elongated forms which are 38 by 24μ in length and breadth. The common forms are 26 by 26μ, 26 by 20μ and less frequently 24 by 14μ. The grains are about the same common size as those of *H. dæones*, though the large grains are slightly less, and no grains are noted whose transverse exceeds the longitudinal axis in length.

Polariscopic Properties.

The *figure* varies from centric to very eccentric, fewer grains of the extremes are present than in *H. dæones*, but a larger number of the mean, hence the average eccentricity is about the same. The figure is usually distinct and clean-cut, and the lines vary from fine to moderately coarse, with more of the former, as in *H. dæones*. The lines usually intersect obliquely though sometimes they are arranged as a median line with bisected ends and rarely intersect at right angles, and there are fewer grains with the last two methods of arrangement than in *H. dæones*. The lines are usually straight with broadening towards the margin, but are sometimes bent and bisected, less frequently than in *H. dæones*. Double and multiple figures are present, but are not quite so numerous as in *H. dæones*.

The *degree of polarization* is high to very high (value 83), variation is frequently present in the same aspect of a given grain; the range of polarization is the same, but fewer grains with a moderately high degree are present, hence the polarization is a little higher than in *H. dæones*.

With *selenite* the quadrants are usually well defined and generally unequal in size and regular in shape, a little more clearly defined and a little more frequently regular than in *H. dæones*. The colors are generally pure, the yellow is less frequently pure than the blue, but the colors are usually purer than in *H. dæones*.

Iodine Reactions.

With 0.25 per cent of Lugol's solution the grains immediately color a moderate bluish violet (value 50), less blue in tint and deeper in color than in *H. dæones;*

the color deepens quickly to moderately deep to very deep, becoming somewhat bluer in tint. With 0.125 per cent Lugol's solution the grains immediately color a light blue-violet, lighter and less bluish than in *H. dæones;* the color deepens quickly from moderate to moderately deep, becoming distinctly bluer, a little lighter in color and a little less reddish than in *H. dæones.* After heating in water until the grains are gelatinized and then adding a 2 per cent Lugol's solution the *grains* color a light to very deep blue, the majority with a reddish tint; the color is lighter and more grains have a reddish tint than in *H. dæones.* The *solution* becomes a very deep indigo-blue, about the same as in *H. dæones.* If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution the *grain-residues* color a moderately light to moderately deep blue, the mean is moderate, many having a slight reddish tint that is lighter than in *H. dæones.* The *capsules* color a moderately light to moderately deep heliotrope, lighter and less reddish in tint than in *H. dæones.* The *solution* colors a very deep indigo-blue, about the same as in *H. dæones.*

Aniline Reactions.

With *gentian violet* the grains stain very lightly at once, a little lighter than in *H. dæones,* and in half an hour they become moderate to moderately deep (value 55), a little lighter than in *H. dæones.*

With *safranin* the grains color very lightly at once and in half an hour they are moderate to moderately deep in color (value 55), the same as in *H. dæones.*

Temperature Reactions.

The majority of the grains are gelatinized at 72° to 73° C., and of all but very rare grains at 73° to 75° C., mean 74° C., practically the same as *H. dæones.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 1 minute. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 18 per cent of the grains and 21 per cent of the total starch in 15 minutes; in about 29 per cent of the grains and 32 per cent of the total starch in 30 minutes; in about 32 per cent of the grains and 36 per cent of the total starch in 45 minutes; in about 36 per cent of the grains and 39 per cent of the total starch in 60 minutes. (Chart D 64.) One or more bubbles, more frequently the former, appear at the hilum, and an enlarged and refractive fissure a little less frequently is seen at the hilum than in *H. dæones.* The lamellæ do not become more distinct as often as in *H. dæones.* The entire grain becomes very refractive and a border of slightly greater refractivity forms around the margin, but it does not broaden so quickly as in *H. dæones.* The methods of gelatinization are very similar to and quite as varied as in *H. dæones.* The pitted appearance of the grain which may precede gelatinization appears much less frequently and when present is more generally localized at the distal margin. The fissures which form during the process of gelatinization are usually not quite so deep nor so branched. The starch at the distal margin of the refractive border is less frequently disorganized into refractive fragments or granules previous to gelatinization. The gelatinized grains are swollen and slightly to considerably distorted, a little more distorted than in *H. dæones,* and, as in this species, they do not usually resemble the form of the untreated grain.

The reaction with *chromic acid* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 10 per cent of the grains and 50 per cent of the total starch in 15 minutes; in about 20 per cent of the grains and 76 per cent of the total starch in 20 minutes; in about 60 per cent of the grains and 85 per cent of the total starch in 25 minutes; in about 86 per cent of the grains and 95 per cent of the total starch in 30 minutes; in more than 99 per cent of both the grains and total starch in 35 minutes; a trace of starch at the margin in a few grains is completely gelatinized in 45 minutes. (Chart D 65.)

The reaction with *pyrogallic acid* begins in a few grains in 1 minute. Complete gelatinization occurs in about 9 per cent of the entire number of grains and 11 per cent of the total starch in 5 minutes; in about 50 per cent of the entire number of grains and 68 per cent of the total starch in 15 minutes; in about 80 per cent of the entire number of grains and 93 per cent of the total starch in 30 minutes; in about 82 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 88 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 66.)

The reaction with *nitric acid* begins in a few grains in half a minute. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 9 per cent of the grains and 12 per cent of the total starch in 15 minutes; in about 14 per cent of the grains and 45 per cent of the total starch in 30 minutes; in about 30 per cent of the grains and 60 per cent of the total starch in 45 minutes; in about 43 per cent of the grains and 65 per cent of the total starch in 60 minutes. (Chart D 67.)

A small bubble appears at the hilum and expands even less, and a fissure is found a little less frequently at the hilum than in *H. dæones,* but it becomes enlarged and refractive as in that parent. The entire grain becomes more refractive and the lamellæ do not usually become more distinct with the exception of one which forms a line of demarcation between the main body and a border of slightly greater refractivity, and the definition of the lamellæ and the demarcation of the main body of the grain and its border is somewhat less sharp than in *H. dæones.* The character and number of the fissures formed during the process is the same and the gelatinization of the grains is varied as in *H. dæones,* but the gelatinization of the border previous to that of the main body of the grain is more frequent, and the refractive granules formed during the reaction are more resistant than in *H. dæones.*

The gelatinized grains are swollen and slightly to much distorted, as in *H. dæones.* Many grains are but partially gelatinized, the same region usually being the most resistant as in *H. dæones.* A number of grains are but little affected by the reagent in 60 minutes, more than in *H. dæones.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 55 per cent of

the entire number of grains and 80 per cent of the total starch in 5 minutes; in about 87 per cent of the grains and 97 per cent of the total starch in 15 minutes; in more than 99 per cent of both the grains and total starch in 30 minutes. (Chart D 68.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in about 25 per cent of the grains and 60 per cent of the total starch in 15 minutes; in about 40 per cent of the grains and 73 per cent of the total starch in 30 minutes; in about 47 per cent of the grains and 77 per cent of the total starch in 45 minutes; in about 52 per cent of the grains and 80 per cent of the total starch in 60 minutes. (Chart D 69.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 14 per cent of the total starch in 5 minutes; in about 30 per cent of the grains and 56 per cent of the total starch in 15 minutes; in about 37 per cent of the grains and 72 per cent of the total starch in 30 minutes; in about 45 per cent of the grains and 74 per cent of the total starch in 45 minutes; in about 50 per cent of the grains and 75 per cent of the total starch in 60 minutes. (Chart D 70.)

The reaction with *potassium iodide* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 7 per cent of the grains and 9 per cent of the total starch in 15 minutes; in about 11 per cent of the grains and 20 per cent of the total starch in 30 minutes; in about 16 per cent of the grains and 25 per cent of the total starch in 45 minutes; in about 22 per cent of the grains and 30 per cent of the total starch in 60 minutes. (Chart D 71.) The hilum, as in *H. dæones,* swells slightly and no bubble is detected there; but the enlarged refractive fissures at the hilum appear with a little less frequency than in *H. dæones.* The entire grain becomes more refractive, but the lamellæ do not appear more distinct with the exception of one which may form a demarcation between the main body and a slightly more refractive border. The definition of the lamellæ and the demarcation of the main body of the grain from the border is a little less sharp than in *H. dæones.* The fissures formed during the process are of similar character but a little less prominent, and the gelatinization of the grains is as varied in character as described in *H. dæones,* but the pitted appearance of the grain previous to gelatinization is less frequent, and more grains are disorganized into more refractive granules previous to gelatinization. The gelatinized grains are swollen and slightly to considerably distorted; a little more distortion than in *H. dæones.* They do not usually resemble the untreated grain as in that parent. Refractive granules in otherwise gelatinized grains are frequently present, and many grains are but little affected at the end of 60 minutes, beyond the swelling of the hilum, even more than in *H. dæones.*

The reaction with *potassium sulphocyanate* begins in a few grains in half a minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 7 per cent of the grains and 12 per cent of the total starch in 15 minutes; in about 25 per cent of the grains and 50 per cent of the total starch in 30 minutes; in about 40 per cent of the grains and 65 per cent of the total starch in 45 minutes; in about 52 per cent of the grains and 75 per cent of the total starch in 60 minutes. (Chart D 72.) The hilum swells somewhat, and becomes as distinct as in *H. dæones,* and if fissures are present in the untreated grain they become larger; if not present they soon appear, usually as a single transverse, oblique, or longitudinal cleft with 2 or 3 large branches which divide the central material into large, irregularly shaped granules. The lamellæ become distinct and then are obscured by fine striæ. Gelatinization usually begins at the hilum, and occasionally in a lenticular-shaped grain at the margin at either end; previous to this the grain becomes covered by fine striæ radiating from the hilum to the margin. The hilum and the grain enlarge, the more resistant material is pushed to the margin where it forms a lamellated, coarsely striated band, which, as gelatinization and swelling go on, becomes transformed into from two to several rows of granules which gradually gelatinize It is to be noted that gelatinization often progresses more rapidly to the margin in one direction than in others, and that there is a fair number of grains in which gelatinization progresses as in *H dæones.* The gelatinized grains are very large, rather thick walled, and somewhat distorted, but bear some resemblance to the untreated grain as in *H. dæones.*

The reaction with *potassium sulphide* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 30 minutes; little if any further advance in 45 minutes; and 4 per cent of the total starch in 60 minutes. (Chart D 73.)

The reaction with *sodium hydroxide* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 6 per cent of the total starch in 15 minutes; in about 17 per cent of the grains and 35 per cent of the total starch in 30 minutes; in about 28 per cent of the grains and 42 per cent of the total starch in 45 minutes; in about 36 per cent of the grains and 48 per cent of the total starch in 60 minutes. (Chart D 74.)

The reaction with *sodium sulphide* begins in a few grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 6 per cent of the grains and 10 per cent of the total starch in 30 minutes; in about 8 per cent of the grains and 14 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 15 per cent of the total starch in 60 minutes. (Chart D 75.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 16 per cent of the entire number of grains and 19 per cent of the total starch in 5 minutes; in about 75 per cent of the grains and 79 per cent of the total starch in 15 minutes; in about 98 per cent of the grains and more than 99 per

cent of the total starch in 30 minutes; in more than 99 per cent of both the grains and total starch in 45 minutes. (Chart D 76.) A small bubble appears at the hilum and in most of the grains is not so frequently inclosed within a fissure, but reacts as described in *H. dæones.* The definition of the lamellæ and the formation of the refractive border is the same as in *H. dæones.* Fissures either proceeding from or intersecting the hilum are less frequently formed just previous to the expulsion of the bubble than in *H. dæones.* Gelatinization begins at the margin of the grain, and the various methods are found which are described in *H. dæones,* but the process in more grains begins at the distal margin and progresses towards the proximal end. The gelatinized grains are swollen and much distorted so that they do not resemble the untreated grain, as in *H. dæones.*

The reaction with *calcium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and also in the total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 30 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 45 minutes; very little if any further advance in 60 minutes. (Chart D 77.)

The reaction with *uranium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 15 minutes; slight progress in 30 minutes; and in about 3 per cent of the grains and 4 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 78.)

The reaction with *strontium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 7 per cent of the total starch in 30 minutes; in about 6 per cent of the grains and 9 per cent of the total starch in 45 minutes; in about 9 per cent of the grains and 14 per cent of the total starch in 60 minutes. (Chart D 79.)

The reaction with *cobalt nitrate* begins in rare grains in 1 minute. Complete gelatinization was not observed among the grains, and the process has begun in but few, much less than 0.5 per cent of both the entire number of grains and total starch, in 5 minutes; complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 30 minutes; about the same in both in 45 and 60 minutes. (Chart D 80.)

The reaction with *copper nitrate* begins in rare grains in half a minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; slight progress in 15 and 30 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 45 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 60 minutes. (Chart D 81.) The reaction proceeds through the mesial region along the course of deep fissures, in elongated forms gelatinization of the distal margin being completed before the proximal end.

The reaction with *cupric chloride* begins in very rare grains in 1 minute. Complete gelatinization occurs in rare grains and has begun in but rare grains, much less than 0.5 per cent, of both the entire number of grains and total starch in 5 minutes; complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 30 minutes; in about 1.5 per cent of the grains and 3 per cent of the total starch in 45 minutes; in about the same in 60 minutes. (Chart D 82.) The reaction proceeds along the fissures through the mesial region, the distal margin being more quickly gelatinized than the proximal end.

The reaction with *barium chloride* begins in very rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains as well as in the total starch in 5 minutes; very little if any progress in 15 minutes; still but rare grains completely gelatinized and 0.5 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 1 per cent of the total in 45 minutes; very little if any further advance in 60 minutes. (Chart D 83.)

The reaction with *mercuric chloride* begins in very rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains as well as in the total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; slight progress in 30 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 45 minutes; very little if any further advance in 60 minutes. (Chart D 84.)

HIPPEASTRUM DÆONES-ZEPHYR (HYBRID).

(Plate 3, fig. 15; Charts D 64 to D 84.)

HISTOLOGIC PROPERTIES.

In *form* the grains are generally simple and isolated. There are more grains in aggregates and more compound grains than in either parent; in this respect the hybrid is nearer to *H. dæones.* The long, slender, finger-like and root-like compound grains and aggregates characteristic of *H. dæones* are not noted here. The grains are less regular than those noted under either parent, but nearer to *H. dæones.* The irregularities are due to the same causes as in the parents. The conspicuous forms are nearly round, round, pure ovoid, and plano-convex. There are also reniform, triangular, and elliptical forms. In form *H. dæones-zephyr* is somewhat nearer *H. zephyr* than *H. dæones,* though the grains of all three starches so closely resemble one another that nearly all differences are of minor importance.

The *hilum* is as distinct as in *H. dæones* and is more frequently fissured than in either parent, and in this the grains are closer to *H. dæones.* The fissures are of the same character as those noted in the parents, with a predominance of the large, irregularly branching, transverse, oblique or longitudinal lines which are more characteristic of *H. zephyr* than those of *H. dæones.* The

hilum is sometimes centric, but usually is eccentric from 0.44 to 0.29, commonly 0.38 of the longitudinal axis. In character and in degree of eccentricity of the hilum *H. dœones-zephyr* is somewhat nearer to *H. dœones* than to *H. zephyr.*

The *lamellæ* are as fine, but not so distinct, as in *H. dœones,* and not so fine but more distinct than in *H. zephyr;* and the arrangement is the same as in both parents. The number counted on the common-sized and larger grains varies from 8 to 20, usually 18. In the character and the number of the lamellæ *H. dœones-zephyr* is somewhat closer to *H. dœones* than to *H. zephyr.*

In *size* the grains vary from the smaller which are 3 by 3μ, to the larger broad forms which are 38 by 34μ, and 38 by 40μ in length and breadth, and the larger elongated forms which are 36 by 28μ, rarely 46 by 34μ in length and breadth. The common-sized grains are 24 by 20μ, 24 by 24μ, and 26 by 20μ; slightly smaller than those of either parent, but the large grains are slightly nearer to those of *H. zephyr.*

Polariscopic Properties.

The *figure* varies from centric to very eccentric as in both parents, but since more of the centric type is present the degree of eccentricity is slightly less than in either parent. The lines have the same character and variation in arrangement as in both parents, but more frequently intersect at right angles than in either parent, in which it is somewhat closer to *H. dœones.* The lines are usually straight and broaden towards the margin, they are less frequently either bent or bisected than in either parent, and hence are little closer in this respect to *H. dœones.* Double and multiple grains are present, but are less frequent than in either parent, which characteristic is closer to *H. zephyr.*

Degree of polarization is high to very high (value 85), and the same range of polarization appears in the individual grains and in the same aspect of a given grain as in the parents, but since much fewer of the moderately high are found, and the variation in the same aspect of a given grain is much less frequent, the degree of polarization is higher than in either parent, but is nearer *H. zephyr.*

With *selenite* the quadrants are usually well defined, the definition is sharper than in either parent, but is closer to *H. zephyr.* The quadrants are unequal in size in the majority of grains, yet they are equal in size in many more grains than in either parent. The colors are usually pure, more frequently than in either parent, but in purity the grains are closer to *H. zephyr.*

In the degree of polarization, the characters of the figures, and the appearances with selenite, *H. dœones-zephyr* is, on the whole, somewhat closer to *H. zephyr* than to *H. dœones,* though being close to both parents, in certain respects closer to one and in others to the other parent. A character found in the parents may be further developed in the hybrid.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains immediately color a moderate blue-violet (value 50), slightly less bluish in tint and somewhat lighter in color than in *H. dœones,* and slightly more bluish in tint, but of the same depth of color as in *H. zephyr;* the color deepens quickly to deep, becoming bluer in tint, a little deeper than in *H. dœones* and the same as in *H. zephyr.* After heating in water until the grains are gelatinized and then adding a 2 per cent Lugol's solution the *grains* color a very light to deep blue, the majority light, the mean being moderately light to moderate, and a reddish tint is rarely present. The color is much lighter and purer than in either parent, but is closer to *H. zephyr.* The *solution* becomes a very deep indigo-blue, the same depth as in both parents. If the preparation is boiled and then treated with an excess of 2 per cent Lugol's solution the *grain-residues* color a light to deep blue, the majority being moderately deep, usually with a reddish tint. They are slightly lighter in color than in *H. dœones* and deeper than in *H. zephyr,* and more reddish in tint than in either parent. The *capsules* color a light to deep old-rose, lighter than *H. dœones* and deeper than in *H. zephyr,* and with more of a reddish tint than in either parent. The *solution* colors a very deep indigo-blue, the same as in both parents. Qualitatively and quantitatively the reaction with iodine shows a close relationship to both parents, but slightly nearer to *H. zephyr* than to *H. dœones.*

Aniline Reactions.

With *gentian violet* the grains stain lightly at once, little lighter than in *H. dœones,* the same as in *H. zephyr;* in half an hour they are moderate in color (value 50), lighter than in either parent, but nearer to *H. zephyr.*

With *safranin* the grains color very lightly at once, the same as in both parents; and in half an hour they become moderate to moderately deep in color (value 55), the same as in both parents.

The reactions with aniline stains show a very close resemblance to both parents, but somewhat nearer to *H. zephyr.*

Temperature Reactions.

The majority of the grains are gelatinized at 72° to 73° C., and of all but very rare grains at 73.5° to 74.5° C., mean 74° C.

The temperature of gelatinization of *H. dœones-zephyr* is the same as of *H. zephyr,* and very little less than of *H. dœones.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 11 per cent of the grains and 13 per cent of the total starch in 15 minutes; in about 13 per cent of the grains and 14 per cent of the total starch in 30 minutes; in about 15 per cent of the grains and 17 per cent of the total starch in 45 minutes; in about 16 per cent of the grains and 18 per cent of the total starch in 60 minutes. (Chart D 64.) One or more bubbles, more frequently the former, appear at the hilum, as in both parents, and an enlarged and refractive fissure is observed at the hilum a little more frequently than in the parents, which is a little closer to *H. dœones.* The lamellæ do not usually become more distinct, not quite so frequently as in *H. dœones,* but as frequently as in *H. zephyr.* The entire grain becomes refractive; and a marginal border of greater

refractivity forms as in the parents; it broadens a little less rapidly than in *H. dæones*, and the same as in *H. zephyr*. The methods of gelatinization are the same as described under both parents. The pitted appearance usually appears in the border, often at one point, and less frequently over the entire surface of the grain than in *H. dæones,* but more frequently than in *H. zephyr*. The border of the grain is sometimes penetrated with moderately deep irregular fissures which may break the border into refractive fragments previous to gelatinization, as in *H. dæones,* but more frequently than in *H. zephyr*. The formation of fissures and of refractive granules during the gelatinization of the grains is the same as in *H. dæones,* a little more prominent than in *H. zephyr*. The gelatinized grains are swollen and slightly to considerably distorted, a little less distortion than in the parents; but a little closer to *H. dæones* than to *H. zephyr* in this respect.

In this reaction *H. dæones-zephyr* shows qualitatively a very close relationship to both parents, but a little closer to *H. dæones* in the more important steps. A character observed in the parents is frequently developed further in the hybrid.

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in about 7 per cent of the entire number of grains and 30 per cent of the total starch in 5 minutes; in about 57 per cent of the grains and 80 per cent of the total starch in 15 minutes; in about 80 per cent of the grains and 90 per cent of the total starch in 20 minutes; in more than 99 per cent of both the grains and the total starch in 25 minutes; only a portion of the margin of a few grains remains ungelatinized. Complete gelatinization occurs in 100 per cent of both the grains and total starch in 30 minutes. (Chart D 65.)

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in about 15 per cent of the entire number of grains and 17 per cent of the total starch in 5 minutes; in about 67 per cent of the grains and 80 per cent of the total starch in 15 minutes; in about 75 per cent of the grains and 96 per cent of the total starch in 30 minutes; in about 85 per cent of the grains and 97 per cent of the total starch in 45 minutes; in about 93 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 66.)

The reaction with *nitric acid* begins in a few grains immediately. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in about 29 per cent of the grains and 34 per cent of the total starch in 15 minutes; in about 50 per cent of the grains and 73 per cent of the total starch in 30 minutes; in about 55 per cent of the grains and 79 per cent of the total starch in 45 minutes; in about 60 per cent of the grains and 85 per cent of the total starch in 60 minutes. (Chart D 67.) A small bubble may appear at the hilum and have the same characteristics as in the parents, but an enlarged fissure is more frequently observed than in either parent, which is a little closer to *H. dæones*. The entire grain becomes very refractive and the lamellæ frequently do not become more distinct, but the definition of both the lamellæ in the main body of the grain and the one lamella forming a line of demarcation between this region and a more refractive border becomes sharper than in either parent, but nearer to *H. dæones*. The fissures formed during the reaction are of similar character and number to those noted in the parents. The gelatinization of the grains is varied as in the parents, but the refractive border is more frequently gelatinized previous to the main body than in the parents, in which *H. dæones-zephyr* more closely resembles *H. dæones*. The most resistant areas are those noted in the parents, but the refractive granules are less resistant than in the parent, in which *H. dæones-zephyr* is closer to *H. dæones*. The gelatinized grains are swollen and slightly to much distorted as in the parents. Many of the grains are but partially gelatinized and some grains are but little affected at the end of 60 minutes, though less than in the parents, in which respect they more closely resemble *H. dæones*. In this reaction *H. dæones-zephyr* shows qualitatively a very close resemblance to the parents, but is a little closer to *H. dæones* than to *H. zephyr*. A character appearing in one parent is often further developed in the hybrid.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 65 per cent of the entire number of grains and 81 per cent of the total starch in 5 minutes; in about 93 per cent of the grains and 97 per cent of the total starch in 15 minutes; in about 98 per cent of the grains and more than 99 per cent of the total starch in 30 minutes. (Chart D 68.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 8 per cent of the total starch in 5 minutes; in about 38 per cent of the grains and 70 per cent of the total starch in 15 minutes; in about 54 per cent of the grains and 78 per cent of the total starch in 30 minutes; in about 58 per cent of the grains and 83 per cent of the total starch in 45 minutes; in about 78 per cent of the grains and 86 per cent of the total starch in 60 minutes. (Chart D 69.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 13 per cent of the entire number of grains and 16 per cent of the total starch in 5 minutes; in about 39 per cent of the grains and 60 per cent of the total starch in 15 minutes; in about 53 per cent of the grains and 70 per cent of the total starch in 30 minutes; in about 61 per cent of the grains and 77 per cent of the total starch in 45 minutes; in about 64 per cent of the grains and 83 per cent of the total starch in 60 minutes. (Chart D 70.)

The reaction with *potassium iodide* begins in a few grains in half a minute. Complete gelatinization occurs in but rare grains, less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 10 per cent of the total starch in 15 minutes; in about 20 per cent of the grains and 27 per cent of the total starch in 30 minutes; in about 23 per cent of the grains and 33 per cent of the total starch in 45 minutes; in about 30 per cent of the grains and 42 per cent of the total starch in 60 minutes. (Chart D 71.)

The hilum swells slightly and a bubble is occasionally detected thereat, also the fissures when present at the hilum become enlarged and more refractive; the presence of a bubble is more frequent and the fissures more

prominent than in the parents, but a little closer to *H. dœones* than to *H. zephyr.* The entire grain becomes very refractive and one lamella often forms a line of demarcation between the main body of the grain and a border of slightly greater refractivity, as in the parents. The lamellæ do not become more distinct in the majority, yet the definition is a little sharper in more grains and the border is a little more prominent than in the parents, and hence there is a closer resemblance to *H. dœones.* The fissures formed during the process are of similar arrangement and character to those of the parents, as prominent as in *H. dœones*, but a little deeper and more prominent than in *H. zephyr.* The gelatinization of the grain is varied in character as in the parents, but the pitted appearance of the grain previous to gelatinization is found in more grains than the parents, hence they have a little closer resemblance to *H. dœones* than to *H. zephyr.* The disorganization of the starch is usually followed by the appearance of refractive granules which are a little less resistant than in the parents and hence closer to those observed in *H. dœones.*

The gelatinized grains are swollen and slightly to considerably distorted, a little more distorted than in either parent, but a little closer to *H. zephyr,* and they do not usually resemble the untreated grain as in the parents. Fewer grains containing refractive granules when otherwise gelatinized are found than in the parents, and also a smaller number which have been but little affected by the reagent are observed than in the parents, hence in this respect more closely following *H. dœones.*

In the reaction with potassium iodide *H. dœones-zephyr* shows qualitatively a very close resemblance to both the parents, but a little nearer to *H. dœones* than to *H. zephyr.* A character found in the parents is often further developed in the hybrid.

The reaction with *potassium sulphocyanate* begins in a few grains immediately. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 8 per cent of the total starch in 5 minutes; in about 28 per cent of the grains and 34 per cent of the total starch in 15 minutes; in about 45 per cent of the grains and 59 per cent of the total starch in 30 minutes; in about 56 per cent of the grains and 62 per cent of the total starch in 45 minutes; in about 58 per cent of the grains and 80 per cent of the total starch in 60 minutes. (Chart D 72.) The hilum enlarges somewhat and is very distinct, as in the parents; and the lamellæ gradually become distinct, but later obscured. The formation of fissures at the hilum and of striæ radiating from the hilum to the margin is the same as in *H. dœones.* Gelatinization usually begins at the hilum, but in a few grains it begins at the margin on either side, as in *H. zephyr.* In the majority of the grains the process of gelatinization is the same as that described under *H. dœones,* but in a few it is the same as that described for a certain number of grains under *H. zephyr.*

The gelatinized grains are large, rather thick-walled, and somewhat distorted, but bear some resemblance to the untreated grain, as in the parents. In this reaction *H. dœones-zephyr,* except in a few grains, shows a closer resemblance to *H. dœones* than to *H. zephyr,* but the reaction shows a very close relationship between both the parents and the hybrid.

The reaction with *potassium sulphide* begins in rare grains in about 1 minute. Complete gelatinization occurs in but rare grains, less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 3 per cent of the total starch in 45 minutes; in about the same percentage of the grains and slight progress, about 4 per cent in the total starch in 60 minutes. (Chart D 73.)

The reaction with *sodium hydroxide* begins in a few grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 11 per cent of the total starch in 15 minutes; in about 19 per cent of the grains and 41 per cent of the total starch in 30 minutes; in about 43 per cent of the grains and 48 per cent of the total starch in 45 minutes; in about 50 per cent of the grains and 58 per cent of the total starch in 60 minutes. (Chart D 74.)

The reaction with *sodium sulphide* begins in very rare grains in 1 minute. Complete gelatinization occurs in only rare grains, less than 0.5 per cent of the entire number of grains and also of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 7 per cent of the total starch in 30 minutes; in about 2 per cent of the grains and 10 per cent of the total starch in 45 minutes; in about 3 per cent of the grains and 14 per cent of the total starch in 60 minutes. (Chart D 75.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 13 per cent of the entire number of grains and 17 per cent of the total starch in 5 minutes; in about 58 per cent of the grains and 65 per cent of the total starch in 15 minutes; in about 92 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 98 per cent of the grains and 99 per cent of the total starch in 45 minutes. (Chart D 76.)

A small bubble appears at the hilum which is a little more frequently inclosed within an enlarged fissure than in the parents, more closely resembling *H. dœones* in this respect. In most of the grains the lamellæ do not become more distinct, yet the definition is sharper in more grains than in the parents. A refractive border is formed as in both parents, but the lamellæ forming the border become clearly defined in more grains. Gelatinization begins and proceeds as noted in the parents, but it advances from the distal to the proximal end in more grains than in *H. dœones,* but in not quite so many as in *H. zephyr.* The resistant starch which may be found either at the proximal end and sides nearby, or in a narrow band at either side of a centric or nearly centric hilum, is more quickly gelatinized than in the parents. In a few grains a delicate fissure may proceed distalwards from the hilum previous to expulsion of the bubble at the hilum as frequently as in *H. dœones* and more frequently than in *H. zephyr.* The gelatinized

grains are swollen and distorted so that they do not resemble the untreated grain, as in both parents.

In the reaction with sodium salicylate *H. dæones-zephyr* shows qualitatively a very close relationship to both parents, the same to one as to the other, but a character which appears in the parents is often further developed in the hybrid.

The reaction with *calcium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and also of the total starch in 5 minutes; complete gelatinization occurs in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 30 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 77.)

The reaction with *uranium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about the same percentage of the grains and 2 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes. (Chart D 78.)

The reaction with *strontium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 9 per cent of the total starch in 30 minutes; in about 6 per cent of the grains and 13 per cent of the total starch in 45 minutes; in about 13 per cent of the grains and 23 per cent of the total starch in 60 minutes. (Chart D 79.)

The reaction with *cobalt nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in rare grains and the process has begun in but few, much less than 0.5 per cent of both the entire number of grains and total starch in 5 minutes; complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 1.5 per cent of the total starch in 30 minutes; about the same in both 45 and 60 minutes. (Chart D 80.)

The reaction with *copper nitrate* begins in rare grains in half a minute. Complete gelatinization occurs in a few grains, less than 0.5 per cent of the entire number of grains and 0.5 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 1.5 per cent of the total starch in 15 minutes; slight progress in 30 minutes; in about 1.5 per cent of the grains and 2 per cent of the total starch in 45 minutes; about the same in 60 minutes. (Chart D 81.) Gelatinization proceeds through the mesial region along the course of deep fissures, the process being completed at the distal margin more rapidly than at the proximal end in elongated grains.

The reaction with *cupric chloride* begins in very rare grains in 1 minute. Complete gelatinization occurs in very rare grains and the process has begun in but rare grains, much less than 0.5 per cent of both the entire number of grains and total starch in 5 minutes; complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 1.5 per cent of the total starch in 30 minutes; very little if any further progress in 45 and 60 minutes. (Chart D 82.)

The reaction with *barium chloride* begins in very rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains, and also the total starch in 5 minutes; in less than 0.5 per cent of the grains and total starch in 15 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes. (Chart D 83.)

The reaction with *mercuric chloride* begins in rare grains in 1 minute. No complete gelatinization was observed among the entire number of grains, but about 1 per cent of the total starch is gelatinized in 5 minutes; in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 3 per cent of the total starch in 30 minutes; very slight advance in 45 minutes; in about 2 per cent of the grains and 4 per cent of the total starch in 60 minutes. (Chart D 84.)

3. HÆMANTHUS.

This genus comprises about 40 species of African bulbous plants which for the most part are natives of the Cape region. Baker (Amaryllideæ, p. 62) divides them into 4 subgenera: *Nerissa, Gyaxis, Melicho,* and *Diacles.*

Starches were obtained from two sets of parent-stocks and hybrids:

5. *Hæmanthus katherinæ* Baker, *H. magnificus* Herb. (*H. puniceus* var. *magnifica* Herb., *H. rouperi*), and the hybrid *H. andromeda.* The specimen of *H. katherinæ* was obtained from E. H. Krelage & Son, Haarlem, Holland; that of *H. magnificus* from Haage & Schmidt, Erfurt, Germany; and that of *H. andromeda* from Van Velsen Brothers, Overveen, Holland.
6. *Hæmanthus katherinæ* Baker, *H. puniceus* Linn. (H. *redoubteanus* Roem.), and the hybrid *H. könig albert.* All three specimens were from the gardens of E. H. Krelage & Son, Haarlem, Holland.

5. Starches of Hæmanthus katherinæ, H. magnificus, and H. andromeda.

Hæmanthus katherinæ (Seed Parent).

(Plates 3 and 4, figs. 16 and 19; Charts D 85 to D 105.)

Histologic Properties.

In *form* the grains are usually simple and isolated with the exception of a small number which occur in aggregates, generally of 2 to 5 components. Pressure facets are rarely observed. Few compound grains of usually 2 or 3, rarely as many as 6, components are present. The grains are frequently irregular, owing chiefly to the following causes: (1) The formation of a secondary set of lamellæ placed at various angles to the primary set; (2) to a slight shifting of the longitudinal axis of the primary set of lamellæ with a resultant curvature at

one end of the grain; (3) to protuberances at different points which vary from small nipple-like to finger-shaped processes. The components of the aggregates are usually compactly arranged, but three in linear arrangement are rarely observed. The conspicuous forms are ellipsoidal, ovoid, elongated ovoid, bean-shaped triangular with rounded angles, pyriform, and lenticular. There are also club-shaped, spindle-shaped, napiform, rod-shaped with curved ends, imperfect quadrangular, T-shaped, and indefinite forms. The grains are somewhat flattened.

The *hilum* is usually very indistinct, but when demonstrable it appears as either a small, round, or elliptical spot which varies in position from centric to quite eccentric. The eccentricity has a range usually of about 0.2 to 0.25, rarely as much as 0.15, of the longitudinal axis. The hilum is, as a rule, not fissured.

The *lamellæ* are usually very indistinct. When observed near the hilum, they form moderately fine rings, which according to the shape of the hilum are circular or elliptical, but most of the lamellæ closely follow the outline of the grain. The lamellæ are rather fine with occasionally one or two that are less fine and located at varying distances from the hilum. On grains of medium size about 8 to 10, and on the larger ones 16, rarely 20, may be counted.

The *size* varies from the smaller which are 4 by 3μ, to the larger which are usually 38 by 20μ, rarely 46 by 20μ, in length and breadth. The common size is about 26 by 14μ.

POLARISCOPIC PROPERTIES.

The *figure* is centric to quite eccentric, and fairly clear-cut. The lines vary from rather fine to quite broad, and more frequently intersect obliquely. In the bean-type they are so arranged as to form a mesial line with bisected ends. The lines are often bent and bisected. Double figures, either in the compound grains or aggregates are rarely observed.

The *degree of polarization* is high to very high (value 75). There is considerable variation in the different grains, the range being from fair to quite high, with the majority fairly high. A variation is also frequently observed in the same aspect of a given grain.

With *selenite* the quadrants are usually well defined in the majority of grains, and usually unequal in size and irregular in shape. The colors may be pure, but sometimes the blue, but more often the yellow, are not quite pure.

IODINE REACTIONS.

With 0.25 Lugol's solution the grains color at once a moderate to light violet (value 45) with a slight reddish tint which deepens rapidly to a moderately deep blue-violet. With 0.125 Lugol's solution the grains color a light violet with reddish tint which gradually becomes slightly deeper and much more blue. After heating in water until the grains are gelatinized, and then adding a 2 per cent Lugol's solution, the *solution* colors a deep indigo-blue, and the gelatinized *grains* a light blue, a few of the larger ones with a reddish tint. If the preparation is boiled for 2 minutes and then treated with an excess of iodine the *grain-residues* color a light dull-blue with a reddish tint, and the *capsules* color a light to a deep old-rose.

ANILINE REACTIONS.

The grains begin to stain immediately, and in half an hour they are colored moderate to deep (value 60).

With *safranin* the grains begin to stain immediately, and in half an hour they are colored moderate to deep (value 60).

TEMPERATURE REACTIONS.

The majority of the grains are gelatinized at 79° to 81° C., and all at 82° to 84° C., mean 83° C.

EFFECTS OF VARIOUS REAGENTS.

The reaction with *chloral hydrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in about 15 per cent of the grains and 20 per cent of the total starch in 15 minutes; in about 47 per cent of the grains and 60 per cent of the total starch in 30 minutes; in about 55 per cent of the grains and 67 per cent of the total starch in 45 minutes; in about 60 per cent of the grains and 74 per cent of the total starch in 60 minutes. (Chart D 85.)

A very small bubble may appear at the hilum which usually expands very little and is very persistent. The lamellæ do not become more distinct. The entire grain becomes more refractive and a very narrow border of greater refractivity forms around the grain, and this border gradually broadens and becomes a little more sharply differentiated. Gelatinization begins at the distal end of grains that have a clearly defined, eccentric hilum, and proceeds toward the proximal end where is located the most resistant starch. In more irregular grains the process may start at any prominent corner; and in elongated grains with nearly centric hilum gelatinization may start simultaneously at both ends and progress towards the hilum. In the last-named grains, as the reaction approaches the hilar region from either end, a cleft furrows through the hilum, accompanied with the expulsion of the bubble thereat, the most resistant starch being a narrow band at either side of the hilar region including the bilateral border. During the process the capsule is distended and much distorted. The resistant starch is often broken into refractive masses and sometimes into refractive granules previous to gelatinization. When a narow band of starch at the proximal end and sides nearby is the most resistant, it may be penetrated by numerous short, deep fissures previous to breaking into linearly arranged refractive granules.

The gelatinized grains are swollen and considerably distorted. Many grains are little affected beyond the initial stages, while others have varying amounts of ungelatinized starch remaining.

The reaction with *chromic acid* begins in very rare grains in 1 minute. Complete gelatinization occurs in very rare grains (less than 0.5 per cent of the entire number) and less than 0.5 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 23 per cent of the total starch in 30 minutes; in about 15 per cent of the grains and 92 per cent of the total starch in 45 minutes; in about 30 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 86.)

The reaction with *pyrogallic acid* begins in a few grains in 1 minute. Gelatinization occurs in about 2

per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; 6 per cent of the entire number of grains and 7 per cent of the total starch in 15 minutes; and in about 8 per cent of the grains and 10 per cent of the total starch in 30 minutes; in about 10 per cent of the grains and 12 per cent of the total starch in 45 minutes; and in about 20 per cent of the grains and 30 per cent of the total starch in 60 minutes. (Chart D 87.)

The reaction with *nitric acid* begins in a few grains in 1 minute. Gelatinization occurs in about 1.5 per cent of the total starch in 5 minutes; in about 2 per cent of the total starch in 15 minutes; in about 2.5 per cent of the entire number of grains and 3 per cent of the total starch in 30 minutes; in about 3 per cent of the grains and 4 per cent of the total starch in 45 minutes; and in about the same percentage of grains and 6 per cent of the total starch in 60 minutes. (Chart D 88.)

The hilum swells and a small bubble which is often quite transient appears at this point. The grains become very refractive, the lamellæ rarely becoming gradually distinct previous to gelatinization. Numerous radiating fissures may extend from the hilum, or there may be one or more copiously branched longitudinal fissures, along the course of which the mesial part of the grain becomes disorganized into very brilliant, irregularly massed, refractive granules, bounded by a refractive border which soon breaks into linearly arranged granules at the distal margin, and later at the proximal end if that becomes gelatinized. All the granules toward the proximal end are more resistant. Gelatinization may begin at the distal end when either that point or both ends of the grain are narrowed. In such grains a longitudinal fissure is sometimes traced from the hilum which becomes much branched towards the distal end followed by gelatinization of a small area accompanied by distention of the capsule, which then assumes the appearance of a small non-granular swelling that is sometimes bounded distally by linear granules.

The almost completely gelatinized grains are swollen, but little distorted, and contain a few brilliant, linearly placed granules. Very few grains, however, exhibit such progress. They usually also contain mesial granules; the capsule at the distal margin occasionally appears to be dissolved and the refractive mesial granules more scattered towards this end; a refractive band at the proximal end and sides retains the outline of the untreated grain. The few completely gelatinized grains are much swollen and considerably distorted.

The reaction with *sulphuric acid* begins in a few grains in 1 minute. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 20 per cent of the entire number of grains and 35 per cent of the total starch in 15 minutes; in about 40 per cent of the grains and 79 per cent of the total starch in 30 minutes; in about 63 per cent of the grains and 90 per cent of the total starch in 45 minutes; and in about 80 per cent of the grains and 94 per cent of the total starch in 60 minutes. (Chart D 89.)

The ungelatinized starch is found at the margin of a few grains and about 1 per cent of all the grains are unaffected to any appreciable degree. The grains become extremely refractive and the polariscopic properties are quickly lowered without evidence of such in any microscopical alteration in the grains.

The reaction with *hydrochloric acid* begins in a few grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the total starch in 5 minutes; in about 3 per cent of the total starch in 15 minutes; in about 4 per cent of the entire number of grains and 10 per cent of the total starch in 30 minutes; in about 12 per cent of the total starch in 45 minutes; and in about 5 per cent of the grains and 15 per cent of the total starch in 60 minutes. (Chart D 90.) Experiment repeated with the same results.

The reaction with *potassium hydroxide* begins in rare grains immediately. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and in about 1 per cent of the total starch in 5 minutes; in about the same in 15 minutes; in about the same percentage of grains and 2 per cent of the total starch in 30 minutes; and in about the same as in the last observation in 60 minutes. (Chart D 91.)

The reaction with *potassium iodide* begins in very few grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the grains and 1.5 per cent of the total starch in 5 minutes; in about the same percentage of each in 15 minutes; in about the same percentage of each in 30 minutes; in about the same percentage of grains and 2 per cent of the total starch in 45 minutes; and in about 1.5 per cent of the grains and less than 3 per cent of the total starch in 60 minutes. (Chart D 92.)

The hilum swells slightly and any fissures thereat become slightly enlarged, but no bubble was detected at this region. The entire grain becomes very refractive and the lamellæ are not usually demonstrable, though occasionally one may be quite distinct and form a line of demarcation between the main body of the grain and a border which is little if any more refractive than the main body of the grain. Fissures start from the hilum which are delicate but varied in relation to the shape of the grain; the fissures are often either unbranched or slightly branched, though many branches may form in the area where considerable gelatinization occurs, such as at the distal end of elongated grains with eccentric hilum. When the longitudinal fissure is unbranched, a deep cluster of small fissures may extend inward from the margin at one or more points previous to disorganization and gelatinization of this area. The course of gelatinization is varied; the most common form is for the process to start along the median fissure and then to be more rapid at one end, gelatinization becoming complete at this point followed by swelling and distortion of the capsule even when the remainder of the grain is but little affected; in elongated grains with a clearly defined eccentric hilum the process may begin at the distal margin and advance gradually towards the proximal end; in another grain with a centric or nearly centric hilum the process may advance from two ends towards the hilum. The mesial region may be disorganized with the appearance of a mass of refractive granules and disruption of the marginal lamellæ into linear granules; but not infrequently the starch may first be broken into large refractive fragments. The most resistant starch is usually located either at the proximal end and sides nearby, or

in a narrow band at either side of the hilum when the process advances from two ends. The starch is frequently more resistant at one than the other side of the hilum.

The completely gelatinized grains are swollen and but little distorted. Some grains are only partially gelatinized, often containing either large refractive masses or very refractive granules. Many grains are but little affected by the reagent with the exception of swelling of the hilum and enlargement of fissures present in the untreated grain.

The reaction with *potassium sulphocyanate* begins in very few grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and in about 2.5 per cent of the total starch in 5 minutes; in about the same percentage of each in 15 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 45 minutes; and in about 2.5 per cent of the grains and 4 per cent of the total starch in 60 minutes. (Chart D 93.) A large percentage of the grains is apparently unaffected.

The hilum swells, but no bubble was detected at this region. The untreated grain is sometimes penetrated by a delicate fissure, in which case an enlargement of this cleft is noted, but no marked refractivity. The lamellæ do not usually become more sharply defined, excepting previous to their disorganization in a few grains. One or two fissures may proceed from the hilum, and sometimes the hilum may be intersected by a fissure. These fissures are generally unbranched and delicate, but occasionally they are sparingly branched and quite deep. Gelatinization more frequently begins by a swelling of the hilum and progression along the course of fissures, the distal end being less resistant. The process may begin almost simultaneously at both ends when the hilum is either centric or but slightly eccentric, the most resistant area then being a band at either side of the hilum. In a few grains gelatinization may begin at a prominent corner or at the distal end, and a deep fissure, which at first has no connection with the hilum, may extend inward from this gelatinized area. The mesial region is often disorganized with the appearance of irregularly arranged refractive granules, and the marginal region, especially the proximal end and sides, into linearly arranged refractive granules. In some grains deep fissures may break the starch into moderately large refractive granules previous to gelatinization.

The gelatinized grains are swollen and but slightly to considerably distorted. Refractive granules are found in many of the grains, often linearly arranged at the proximal end and sides nearby. Some of the gelatinized grains bear a general resemblance to the untreated grain.

The reaction with *potassium sulphide* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 1 per cent of the entire number of grains and in about 1 per cent of the total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in 1 per cent of the grains and 2 per cent of the total starch in 30 minutes; in about the same percentage of each in 45 minutes; and in about the same percentage of each in 60 minutes. (Chart D 94.) A very few grains are fairly soon completely or almost completely gelatinized, with but little additional effect, a peculiarity observed in all six of the Hæmanthuses except *H. puniceus*.

The hilum swells; either one or two fissures leave the hilum and proceed distalward, which may remain clean-cut, but often become branched towards the distal end. One lamella frequently becomes very distinct and serves as a boundary between the mesial portion and a very refractive border; occasionally a few lamellæ become distinct through the mesial portion between two obliquely directed longitudinal fissures. The mesial portion of the grain is usually disorganized with the appearance of quite refractive irregularly arranged granules, and of a narrow marginal border of very refractive, linearly arranged granules.

The gelatinized grain is much swollen, and when completely gelatinized is slightly distorted, but many are gelatinized with the exception of either linear marginal granules or a deeply striated, narrow marginal border.

The reaction with *sodium hydroxide* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 1 per cent of the entire number of grains and in about 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 2.5 per cent of the total starch in 15 minutes; in about the same percentage of each in 30 minutes; in about the same percentage of grains and a slight increase in the percentage of total starch in 45 minutes; and in about the same percentage of grains and 3 per cent of the total starch in 60 minutes. (Chart D 95.) The hilum swells very slowly, and no bubble is detected at the point. Very gradually one lamella situated at varying distances from the hilum (frequently about 0.66 of the longitudinal axis), and sometimes a few near the margin, may become more distinct. Either one or two delicate fissures proceed from the hilum which are usually clear-cut, but may branch toward the distal end. The mesial region breaks down into very refractive granules; a narrow marginal border which may be entire or extend only around the proximal end and sides is very resistant, it becoming very refractive and profusely striated, finally breaking down into very refractive granules, linearly arranged, before gelatinization. The distal end is the first point of this marginal border to become gelatinized, and when the fissure is branched at this end the reaction may be completed at this point previous to that at the mesial margin. The gelatinized grain is much more swollen.

The reaction with *sodium sulphide* begins in rare grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and about 1.5 per cent of the total starch in 5 minutes; in about the same percentage of each in 15 minutes and in 30 minutes; in about the same percentage of grains and 2 per cent of the total starch in 45 minutes; and in about the same percentage of each in 60 minntes. A very few grains are quickly attacked by the reagent but apart from this there is very little effect. (Chart D 96.)

The reaction with *sodium salicylate* begins in 30 seconds. Complete gelatinization occurs in about 68 per cent of the entire number of grains and about 80 per cent of the total starch in 5 minutes; in about 98 per cent of the grains and over 99 per cent of the total starch in 15 minutes; in over 99 per cent of both grains and total

starch in 20 minutes; and in all in 60 minutes. (Chart D 97.)

A small bubble appears at the hilum which very rarely is inclosed within a fissure, and it is very persistent, expanding very little if any previous to expulsion. The lamellæ do not become any more distinct, but a border is formed which is slightly more refractive than the rest of the grain. In the grains with either a centric or slightly eccentric hilum gelatinization begins at both ends, and then the process later is usually more rapid from one end than the other, and as it approaches the hilum either a clear narrow space or a delicate fissure is furrowed through the resistant area as the bubble is expelled. In the grains with a quite eccentric hilum gelatinization begins at the distal margin and advances slowly toward the hilum; just previous to the expulsion of the bubble a mesial fissure proceeds towards the proximal end which becomes gelatinized previous to the sides nearby, hence, even in such grains a narrow band on either side of the hilum is the most resistant starch.

The gelatinized grains are swollen and distorted so that they do not resemble the untreated grain. Either partial or complete solution may follow gelatinization.

The reaction with *calcium nitrate* begins in rare grains in 30 seconds. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and in about 1 per cent of the total starch in 5 minutes; in about the same percentage of each in 15, 30, 45, and 60 minutes, respectively. A few grains are quickly gelatinized but apart from this there is extremely little effect. (Chart D 98.)

The reaction with *uranium nitrate* begins in rare grains in 30 seconds. Complete gelatinization occurs in 0.5 per cent of the entire number of grains and in less than 1 per cent of the total starch in 5 minutes; in about the same percentage of grains and 1.25 per cent of the total starch in 15 minutes; and in about the same percentage of each in 30, 45, and 60 minutes, respectively. A very few grains are quickly gelatinized but there is very little action beyond this. (Chart D 99.)

The reaction with *strontium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and in about 2 per cent of the total starch in 5 minutes; in about the same percentage of grains and 3 per cent of the total starch in 15 minutes; and in about the same percentage of each in 30, 45, and 60 minutes, respectively. (Chart D 100.)

The reaction with *cobalt nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in a few grains and the process has begun in but few, less than 0.5 per cent of both the entire number of grains and the total starch, in 5 minutes; very little progress in 15 minutes; complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 30 minutes; about the same in 45 and 60 minutes. (Chart D 101.)

Gelatinization usually proceeds through the mesial portion of the grains, preceded by the formation of delicate fissures in some of the grains. The entire margin is for a time resistant, but finally in complete gelatinization the proximal end proves the most resistant. When the grains are considerably elongated the process may begin at one or both ends (when the hilum is almost centric) but eventually proceeds more rapidly from the end which is farthest from the hilum.

The reaction with *copper nitrate* begins in rare grains in half a minute. Complete gelatinization occurs in very rare grains and the process has begun in much less than 0.5 per cent, of both the entire number of grains and of the total starch, in 5 minutes; slight progress in 15, 30, 45, and 60 minutes, until at the end of this period complete gelatinization occurs in about 0.5 per cent of the entire number of grains and in about 1.5 per cent of the total starch. (Chart D 102.) Gelatinization proceeds through the mesial portion along the course of fissures, the distal end being gelatinized before the proximal end.

The reaction with *cupric chloride* begins in very rare grains in 1 minute. Complete gelatinization was not observed in any grains and the process has begun in but rare grains, much less than 0.5 per cent of both the entire number of grains, and the total starch in 5 minutes; complete gelatinization occurs in rare grains and the process is begun in but rare grains in 15 minutes; no apparent progress in 30, 45, and 60 minutes, respectively, at the end of which period less than 0.5 per cent of both the entire number of grains and the total starch is gelatinized. (Chart D 103.) Gelatinization proceeds through the mesial region along the fissures, the distal margin being gelatinized much more rapidly than the proximal end. In some grains the distal margin is gelatinized, accompanied by some extension but no fluting of this distal end before the mesial portion towards the hilum is much affected.

The reaction with *barium chloride* begins in very rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; and in about the same percentage of each in 15, 30, 45, and 60 minutes, respectively. (Chart D 104.)

The reaction with *mercuric chloride* begins in rare grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1.25 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 0.5 per cent of the total starch in 15 minutes; about the same in 30, 45, and 60 minutes, respectively. (Chart D 105.) There are a few scattered grains in this preparation that are quickly gelatinized, while almost all are very resistant.

Hæmanthus magnificus (Pollen Parent).

(Plate 3, fig. 17; Charts D 85 to D 105.)

Histologic Properties.

In *form* the grains are usually simple and isolated. There are more small aggregates of 2, 3, or 4 grains than in *H. katherinæ,* and there are compound grains consisting of 2 to 4 components inclosed in a number of secondary lamellæ which have not been seen in *H. katherinæ.* The components of the compound grains are linearly or pyramidally arranged or, when there are 4 or more in a compact group, they are separated from one another by fissures which do not extend to the margin of the grain. The grains are somewhat more frequently irregular in form than in *H. katherinæ,* but there is not much difference between the two starches in this respect. The iregularities are due to the following causes: (1) To a

shifting of the longitudinal axis of the primary lamellæ producing a curvature at one end of the grain; (2) to nipple-like, large, rounded, or finger-like protuberances at various points. The grains tend to be somewhat broader and to have more rounded ends than those noted under *H. katherinæ*. The conspicuous forms are pointed and pure ovoid, elliptical, plano-convex, and nearly round. There are also scalene-triangular, reniform, pyriform, and irregularly quadrilateral forms.

The *hilum* is a moderately distinct, small, round, or lenticular spot, and often fissured. It is more distinct and much more frequently fissured than in *H. katherinæ*. The fissures take the following forms: (1) An irregularly shaped cavity from which small fissures radiate; (2) a single, short, straight or slightly convex line with some small fissures branching from it, lying transversely or longitudinally; (3) irregularly V- and Y-shaped; (4) flying-bird form. The hilum may be either centric or eccentric. The range of eccentricity is from 0.45 to 0.15 usually 0.35 of the longitudinal axis—about the same as in *H. katherinæ*.

The *lamellæ* are usually rather indistinct, though less indistinct than in *H. katherinæ*, and when they can be seen they are rather fine, continuous lines, circular, ovoid, or lenticular in form when near the hilum, and taking the form of the outline of the grain elsewhere. There is often one broad refractive lamella which may be situated at varying distances from the hilum. From 12 to 30, usually about 20, may be counted on the larger grains.

The *size* of the grains varies from the smaller which are 3 by 3μ, to the larger broad forms which are 48 by 40μ, and the larger narrow forms which are 50 by 38μ, in length and breadth. The common sizes are 34 by 30μ and 32 by 20μ. The grains of this starch are larger and tend to be somewhat broader in proportion to their length than those of *H. katherinæ*.

Polariscopic Properties.

The *figure* varies from centric to quite eccentric, more of the former than in *H. katherinæ*, and the figure is usually distinct and clean-cut, more so than in *H. katherinæ*. The lines vary from fine to moderately coarse, with more of the former; the mean being finer than in *H. katherinæ*. In the majority of grains the lines intersect obliquely, but the intersection is at right angles in a considerable number; more of the latter than in *H. katherinæ*. The lines are also not infrequently arranged as a median line with bisected ends, more of this type being observed than in *H. katherinæ*. The lines are more frequently straight, but they are occasionally bent and moderately often bisected; they are less frequently bent, but the bisection is about the same as in *H. katherinæ*. Compound and multiple figures are not uncommon, but more numerous than in *H. katherinæ*.

The *degree of polarization* is very high (value 90). The polarization varies from high to very high in the different grains, and there is some variation in the same aspect of a given grain, the variation both in the former and the latter is less common than in *H. katherinæ*, and hence the degree of polarization is much higher than in *H. katherinæ*.

With *selenite* the quadrants are usually well defined, more frequently unequal in size and generally regular in shape; the definition is sharper; they are more often equal in size, and the regularity is much greater than in *H. katherinæ*. The colors are generally pure, the purity not so marked in the yellow as in the blue; the impurity results more frequently from an extremely high degree of polarization which imparts a greenish tinge to both colors; the colors are more frequently pure, although the type of impurity above described is not present in *H. katherinæ*.

Iodine Reactions.

With 0.25 Lugol's solution the grains color a moderate violet (value 50), which is a little more bluish and deeper than in *H. katherinæ*; the color deepens more rapidly to a greater depth and becomes more blue than in *H. katherinæ*. With 0.125 per cent solution the *grains* color a light violet, a little deeper and more blue in tint than in *H. katherinæ*, the color gradually deepens to a moderate grade, a little deeper than in *H. katherinæ*. (Studies of the iodine reactions were limited because of insufficient material.)

Aniline Reactions.

With *gentian violet* the grains color very faintly at once, in half an hour becoming moderate to deep (value 55), some deeper than others, but not so deep as in *H. katherinæ*.

With *safranin* the grains color very lightly at once and in half an hour they become moderate to deep (value 60), of about the same depth as in *H. katherinæ*.

Temperature Reactions.

The majority of the grains are gelatinized at 77° to 77.5° C.; and of all at 78° to 79°, mean 78.5° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 8 per cent of the grains and 14 per cent of the total starch in 15 minutes; in about 11 per cent of the grains and 15 per cent of the total starch in 30 minutes; in about 14 per cent of the grains and 17 per cent of the total starch in 45 minutes; and little if any further change in 60 minutes. (Chart D 85.)

A bubble appears at the hilum which expands to greater size than in *H. katherinæ*. The fissure when present becomes enlarged and refractive, which was not observed in *H. katherinæ*. The lamellæ do not generally become more distinct, though slightly more frequently than in *H. katherinæ*. A well-defined refractive border is formed, and a very distinct lamella frequently constitutes a line of demarcation between the main body of the grain and the refractive border, the latter being much more prominent than in *H. katherinæ*. In some grains gelatinization may begin and proceed as in *H. katherinæ*, but in others it begins at one point in the border and spreads around the grain, and occasionally progresses rather quickly through the mesial region, the refractive border proving the more resistant. The starch is sometimes disorganized with the appearance of refractive fragments or granules, the latter often being observed at an earlier stage in the process of gelatinization than in *H. katherinæ*. Deep, short fissures may form in the most resistant part of the grain previous to gelatinization, and

the reaction is accompanied by distortion and distention of the capsule, as noted for *H. katherinæ*.

The gelatinized grains are swollen and distorted as in *H. katherinæ*. Many of the grains are but little affected beyond the initial stages, many more than in *H. katherinæ*. The bubble at the hilum persists and is frequently much expanded in such grains.

The reaction with *chromic acid* begins in a few grains immediately. Complete gelatinization occurs in but rare grains, less than 0.5 per cent of the entire number, and 3 per cent of the total starch in 5 minutes; in about 0.5 per cent of the grains and 19 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 27 per cent of the total starch in 30 minutes; in about 17 per cent of the grains and 86 per cent of the total starch in 45 minutes; in about 21 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 86.)

The reaction with *pyrogallic acid* begins in a few grains in 1 minute. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in about 15 per cent of the grains and 20 per cent of the total starch in 15 minutes; in about 56 per cent of the grains and 60 per cent of the total starch in 30 minutes; in about 52 per cent of the grains and 76 per cent of the total starch in 45 minutes; and in about 60 per cent of the grains and 86 per cent of the total starch in 60 minutes. About 15 per cent of the grains are but little affected. (Chart D 87.)

The reaction with *nitric acid* begins in a few grains immediately. Complete gelatinization occurs in about 2.5 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 12 per cent of the grains and 40 per cent of the total starch in 15 minutes; in about 30 per cent of the grains and 45 per cent of the total starch in 30 minutes; in about the same number of grains and 48 per cent of the total starch in 45 minutes; in about 32 per cent of the grains and 50 per cent of the total starch in 60 minutes. (Chart D 88.)

A small bubble appears at the swollen hilum which in the majority of grains is not inclosed within an enlarged fissure, but is found in such a fissure in many more grains than in *H. katherinæ*. The grains become very refractive and the lamellæ do not usually become more distinct with the exception of one which serves as a boundary between the main body of the grain and a refractive border; this lamella and the refractive border were but very rarely observed in *H. katherinæ*. The fissures present in the untreated grain become more prominent, and when not present they are so formed as to pass through the hilum or radiate from it in the centric and bean-type forms, and extending toward the distal margin in grains with an eccentric hilum. These fissures do not usually extend through the refractive border. The fissures are deeper, more branched throughout the entire length, and much less frequently extend to the distal margin, than in *H. katherinæ*. Gelatinization usually begins in the refractive border, it may extend very rapidly around the entire grain, especially when of a rounded type, or begin at either the proximal or the distal margin, but eventually extends around the entire grain before gelatinization has made much progress in the main body of the grain. This border immediately becomes much ruffled in many grains and later much extended and less folded, and finally may pass into solution. In some of the grains gelatinization begins in the border, and the lamellæ (between the main body of the grain and the outermost lamella) are disorganized with the appearance of irregularly arranged refractive granules. The border swells but does not become distorted, the outermost lamella now breaking down into linearly arranged refractive granules which may or may not eventually become gelatinized. The methods of gelatinization above described were not observed in *H. katherinæ*. The main body of the grain is penetrated by deep fissures and in many grains no further progress is made, but in others this starch is broken down into large, very refractive granules, some of which usually remain. In a few grains, either after the solution of the border or when the border is not very prominent, an area near the distal margin may become gelatinized, accompanied by distention of the capsule at this point, the gelatinized area sometimes being bounded by a layer of linearly arranged granules, this method having been noted with greater frequency in *H. katherinæ*. The partially gelatinized grains which are quite common, consist of the main body of the grain which is not much swollen, but frequently penetrated by deep fissures, and which is surrounded by a much swollen border which may be either not or only little distorted. In grains which have become more gelatinized, the area around the hilum usually contains large refractive granules, such grains usually being much swollen and considerably distorted. The partially gelatinized grains described above are not observed in *H. katherinæ*, and the others exhibit more distortion than in *H. katherinæ*.

The reaction with *sulphuric acid* begins in a few grains immediately. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 50 per cent of the grains and 75 per cent of the total starch in 15 minutes; in about 67 per cent of the grains and 87 per cent of the total starch in 30 minutes; in about 86 per cent of the grains and 97 per cent of the total starch in 45 minutes; and in 97 per cent of the grains and over 99 per cent of the total starch in 60 minutes. (Chart D 89.)

The reaction with *hydrochloric acid* begins in a few grains in 1 minute. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in about 25 per cent of the grains and 35 per cent of the total starch in 15 minutes; in about 51 per cent of the grains and 66 per cent of the total starch in 30 minutes; in about 67 per cent of the grains and 75 per cent of the total starch in 45 minutes; and in about 70 per cent of the grains and 83 per cent of the total starch in 60 minutes. (Chart D 90.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 9 per cent of the total starch in 15 minutes; in about 8 per cent of the grains and 11 per cent of the total starch in 30 minutes; in about the same percentage in 45 minutes; and in about 10 per cent of the grains and 20 per cent of the total starch in 60 minutes. (Chart D 91.)

The reaction with *potassium iodide* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 1 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 15 minutes; in about 2.5 per cent of the grains and 4.5 per cent of the total starch in 30 minutes; in nearly 3 per cent of the grains and 7 per cent of total starch in 45 minutes; and in about 5 per cent of the grains and 12 per cent of total starch in 60 minutes. (Chart D 92.)

The hilum swells and the fissures present in the untreated grain become enlarged and more refractive but no bubble was detected as in *H. katherinæ*. The hilum swells more and the fissures thereat are more common and become more enlarged and refractive, than in *H. katherinæ*. The entire grain becomes very refractive and the lamellæ are not usually distinct, with the exception of one lamella, which often forms a line of demarcation between the main body of the grain and a marginal border which is even more refractive than the body of the grain. This lamella and the refractive border are much more frequent than in *H. katherinæ*. The fissures are much deeper and more profusely branched than in *H. katherinæ*. The course of gelatinization is varied, but the most common form is for the border to become differentiated into its component lamellæ and quickly gelatinize without the appearance of refractive granules, with the exception of a marginal row of linear granules; the process advances almost simultaneously in the body of the grain along deep fissures through the mesial region, forming a mass of very refractive granules surrounded by one to few rows of linearly arranged granules. The border may remain as a narrow, clear band, but frequently after the linear granules bounding it are gelatinized, distortion may start at one point and spread around the margin or be limited to one end. The starch much more frequently breaks down into very refractive granules and much less frequently into refractive masses than in *H. katherinæ*. The form of gelatinization most commonly observed in this species was not noted in *H. katherinæ*. In some grains the most resistant starch may be at the proximal end and sides nearby as is frequently found in *H. katherinæ*, but it is much more frequently located in the border of the main body of the grain, this not having been observed in *H. katherinæ*.

The gelatinized grains are swollen and slightly to considerably distorted, more distortion than in *H. katherinæ*. Many grains remain with refractive granules, and many are little affected beyond the swelling of the hilum and enlargement of fissures; the reaction, however, has advanced further in many more grains than in *H. katherinæ*.

The reaction with *potassium sulphocyanate* begins in half a minute. Complete gelatinization occurs in about 1.5 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in about 9.5 per cent of the grains and 11 per cent of the total starch in 15 minutes; in about 17 per cent of the grains and 22 per cent of the total starch in 30 minutes; in about 28 per cent of the grains and 34 per cent of the total starch in 45 minutes; and in about 33 per cent of the grains and 40 per cent of the total starch in 60 minutes. (Chart D 93.) Many grains are wholly unaffected.

The hilum swells but no bubble was detected, as noted in *H. katherinæ*. A fissure which is frequently found at the hilum in the untreated grain becomes enlarged and sometimes more refractive; this being much more prominent than in *H. katherinæ*. The lamellæ of some grains become more distinct, notably one which may form a boundary line between the main body of the grain and a refractive border, and there occurs a gradual differentiation of the lamellæ in this border. (The refractive border is present in the untreated grain.) The fissures are deeper and more frequently branched than in *H. katherinæ*. The most common type of fissure is thorn-like, and also numerous radiating fissures are formed in grains of a more rounded type, which fissures are not similar to those usually found in *H. katherinæ*. The methods of gelatinization described in *H. katherinæ* are occasionally observed, but the most common type is quite dissimilar to the usual methods in *H. katherinæ*. Gelatinization usually begins with the swelling of the hilum and advances along the course of well-defined fissures after considerable progress in the main body of the grain, and the process often starts at the boundary between this region and the border and then advances through the border which loses its structure and becomes semi-transparent, often with the exception of a narrow very refractive marginal band. In many grains no further progress in gelatinization occurs, while in others the process may start at one point of this semi-transparent border followed by distention and much distortion of the capsule, and the granules in the main body as well as the more resistant layers of starch may undergo complete gelatinization. The general methods above described are not observed in *H. katherinæ*. The starch in the mesial region of the main body of the grain is disorganized with the appearance of brilliant irregularly massed granules, usually more refractive and numerous than in *H. katherinæ*. The marginal layers of the main body of the grain become deeply striated and generally disorganized into linear granules previous to gelatinization, these are similar to but more frequently found around the entire grain than in *H. katherinæ*. When a border is present, as occurs in many grains, the reaction usually spreads through this without the formation of granules, but it may disorganize into granules if the outermost refractive layer is gelatinized; the gelatinization of such a border was not observed in *H. katherinæ*. The breaking of the grain into a few fairly large refractive fragments previous to gelatinization is very rarely observed, with much less frequency than in *H. katherinæ*.

The gelatinized grains are much swollen and slightly to considerably distorted, the distortion is more frequent than in *H. katherinæ*. Many grains still contain a number of refractive granules which more frequently inclose the entire margin of the grain or the main body within a translucent border. The reaction has advanced to this stage in many more grains, as well as reached complete gelatinization of a much larger number than in *H. katherinæ*.

The reaction with *potassium sulphide* begins in a few grains in half a minute. Complete gelatinization occurs in less than 1 per cent of the entire number of grains and total starch in 5 minutes; in about the same percentage in 15 minutes; in about 1 per cent of the grains and 2.5

per cent of the total starch in 30 minutes; in about the same percentage in 45 minutes; and in about the same in 60 minutes. (Chart D 94.) (Insufficient material to study qualitative reaction.)

The reaction with *sodium hydroxide* begins in a few grains in half a minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 12 per cent of the grains and 15 per cent of the total starch in 15 minutes; in about 20 per cent of the grains and 24 per cent of the total starch in 30 minutes; in about the same percentage of grains and 27 per cent of the total starch in 45 minutes; and in about 28 per cent of the grains and 35 per cent of the total starch in 60 minutes. (Chart D 95.)

The reaction with *sodium sulphide* begins in a few grains in half a minute. Complete gelatinization occurs in about 1.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 3.5 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 6 per cent of the grains and 7.5 per cent of the total starch in 30 minutes; in about 7 per cent of the grains and 9 per cent of the total starch in 45 minutes; and in about 8 per cent of the grains and 9.5 per cent of the total starch in 60 minutes. (Chart D 96.)

The reaction with *sodium salicylate* begins in half a minute. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 9.5 per cent of the total starch in 5 minutes; in about 30 per cent of the grains and 36 per cent of the total starch in 30 minutes; in about 67 per cent of the grains and 70 per cent of the total starch in 30 minutes; in about 90 per cent of the grains and 95 per cent of the total starch in 45 minutes; and in over 97 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 97.)

A small bubble appears at the hilum which in the majority of grains is not inclosed within an enlarged fissure; this bubble, however, is found in more grains and expands to greater size than in *H. katherinæ*. The lamellæ do not become sharply defined in most of the grains, though in more than in *H. katherinæ.* A refractive border is formed which is frequently sharply defined from the main body of the grain, and in which the lamellæ sometimes become sharply defined previous to sudden gelatinization of this border. The methods of gelatinization are more varied and the process is less rapid than in *H. katherinæ,* the latter being rather remarkable since with many reagents the reverse is found. The same methods of gelatinization are found as noted for *H. katherinæ,* and in addition the lamellæ of the refractive border may become very sharply defined, followed by sudden gelatinization of this border without distortion; complete solution often then occurs in this gelatinized border and the reaction proceeds in the remaining body of the grain according to methods described in *H. katherinæ.*

The gelatinized grains are swollen and distorted, but less distortion is found than in *H. katherinæ;* either partial or complete solution more quickly follows gelatinization in the border of the grain than in *H. katherinæ.*

The reaction with *calcium nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2.5 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 3.5 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 5 per cent of the total starch in 30 minutes; in about 5 per cent of the grains and 5.5 per cent of the total starch in 45 minutes; and in about 5.2 per cent of the grains and 6 per cent of the total starch in 60 minutes. (Chart D 98.)

The reaction with *uranium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 1.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about the same percentage in 15 minutes; in about 3 per cent of the grains and 3.5 per cent of the total starch in 30 minutes; in about 3.5 per cent of the grains and 5 per cent of the total starch in 45 minutes; and in about the same percentage of each in 60 minutes. (Chart D 99.)

The reaction with *strontium nitrate* begins in rare grains in half a minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 1.5 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 6.5 per cent of the total starch in 30 minutes; in about 5 per cent of the grains and 8 per cent of the total starch in 45 minutes; and in about 6.5 per cent of the grains and 9 per cent of the total starch in 60 minutes. (Chart D 100.)

The reaction with *cobalt nitrate* begins in rare grains in half a minute. Complete gelatinization was not observed among the entire number of grains, and the process has begun in but few, much less than 0.5 per cent in both the entire grains and total starch in 5 minutes; very slight progress in 15 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 30 minutes; very slight if any progress in 45 and 60 minutes, respectively. (Chart D 101.)

The reaction with *copper nitrate* begins in very rare grains in half a minute. Complete gelatinization occurs in but rare grains and the process has begun in but few, less than 0.5 per cent of the entire number of grains and about 0.5 per cent of the total starch gelatinized in 5 minutes; very slight progress occurs in 15 minutes; about 0.5 per cent of the grains completely gelatinized and about 1 per cent of the total starch in 30 minutes; about the same in 45 and 60 minutes, respectively. (Chart D 102.) In the few grains affected, gelatinization begins at the distal end accompanied by distention of the capsule when the grains are elongated, but along the course of fissures through the mesial region in the more rounded forms.

The reaction with *cupric chloride* begins in rare grains in 1 minute. Complete gelatinization was not observed in any grain and the process has begun in but few, much less than 0.5 per cent of both the entire number of grains and of the total starch in 5 minutes; still no complete gelatinization noted but about 0.5 per cent of the total starch gelatinized in 15 minutes; complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1.5 per cent of the total starch in 30 minutes; slight progress in 45 minutes; in about 1

per cent of the grains and 3 per cent of the total starch in 60 minutes. (Chart D 103.)

Gelatinization may proceed along well-defined fissures through the mesial region, but more often before much progress is made in the mesial region it may advance rapidly at the distal end of elongated grains or around the entire margin of ovoid grains, the process being accompanied with extension and considerable fluting of the capsule. This fluting is more marked than in *H. katherinæ.*

The reaction with *barium chloride* begins in rare grains in half a minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about the same percentage of each in 35 minutes; in about the same percentage in 30 and 45 minutes; and in less than 0.5 per cent of the grains and about 1 per cent of the total starch in 60 minutes. (Chart D 104.)

The reaction with *mercuric chloride* begins in rare grains in 1 minute. Complete gelatinization occurs in but rare grains and the process begun in but few, less than 0.5 per cent of both the entire grains and total starch in 5 minutes; about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; about 1 per cent of the grains and 0.5 per cent of the total starch in 30 minutes; little if any further progress in 45 and 60 minutes, respectively. (Chart D 105.)

Hæmanthus andromeda (Hybrid).

(Plate 3, fig. 18; Charts D 85 to D 105.)

Histologic Properties.

In *form* the grains are usually simple and isolated with the exception of a few which occur in aggregates of 2, 3, or 4 components. There are some compound grains, but not so many as in *H. magnificus.* The latter usually are doublets, but may have 3 or 4, or very rarely more, components, and they are similar in appearance and arrangement to those seen under *H. magnificus.* The grains tend to be more irregular in form than in either parent, and the irregularities are due to the following causes: (1) Protuberances which are usually finger-like, but which may be large and rounded or nipple-like; (2) to a shifting of the longitudinal axis causing a curvature at one end; (3) to moderately well-defined pressure facets of varying size and position; (4) to depressions and notches in the margin, one deep semi-circular depression at the distal end being characteristic of this grain as distinguished from those of the parents. The components of the aggregates are usually compactly arranged, but 3 or 4 in linear arrangement are observed. The conspicuous forms are ovoid, elliptical, broad lenticular, plano-convex, and dome-shaped. There are also scalene and isosceles triangular, broad reniform, pyriform, almost round, and irregularly quadrilateral forms. In form the grains of *H. andromeda* more nearly resemble those of *H. katherinæ, but* there are some scattered grains which are exactly like those characteristic of *H. magnificus.*

The *hilum* is indistinct and when seen is a small, round or lenticular spot which is very seldom fissured. It may be either centric or eccentric from 0.43 to 0.2 usually 0.3, of the longitudinal axis. In the characters of the hilum *H. andromeda* more closely resembles *H. katherinæ* than *H. magnificus.*

The lamellæ are so indistinct that it is impossible to form any satisfactory comparison between the hybrid and parents; when they can be demonstrated, they appear as circular or lenticular in form and throughout the rest of the grain they have the form of the outline of the grain. Those counted on the larger grains vary from 10 to 25, usually about 18.

In *size* the grains vary from the smaller which are 4 by 4μ to the larger broadened forms which are 50 by 40μ, and the large, narrow forms which are 50 by 30μ in length and breadth. The common size is about 30 by 18μ. In size *H. andromeda* is closer to *H. magnificus* than to *H. katherinæ.*

Polariscopic Properties.

The *figure* is centric to quite eccentric, considerably less eccentric than in *H. katherinæ,* but distinctly more than in *H. magnificus.* The lines vary from fine to coarse, more of the latter than in *H. katherinæ,* and many more than in *H. magnificus.* The lines intersect each other or are arranged as a median line with bisected ends as noted in both parents; the intersection is at right angles in more grains than in *H. katherinæ,* but in many less than in *H. magnificus.* The lines are more frequently straight, and not quite so often bent as in *H. katherinæ* but more frequently than in *H. magnificus.* The lines are often bisected, about as in both parents. Compound and multiple figures are not commonly present, though more frequently than in *H. katherinæ,* but not nearly so often as in *H. magnificus.*

The *degree of polarization* is high to very high (value 82). There is a great deal of variation among the individual grains, the polarization ranging from a few moderately high to some very high, most of them being high; the variation in the different grains is about as great but the mean is higher than in *H. katherinæ,* and the variation is greater and the mean lower than in *H. magnificus.* The variation in the same aspect of a given grain is not so frequent as in *H. katherinæ* but very much more common than in *H. magnificus.*

With *selenite* the quadrants vary from not very well defined to quite sharply defined. The definition is sharper in more grains than in *H. katherinæ* but not as sharp in nearly so many as in *H. magnificus.* In the majority of grains the quadrants are unequal in size and often irregular in shape, not quite so unequal and irregular as in *H. katherinæ* but decidedly more so than in *H. magnificus.* The colors are generally pure, the blue more frequently than in *H. katherinæ,* but not so frequently as in *H. magnificus;* the type of impurity is often due to the presence of grains having an extremely high degree of polarization, imparting a greenish tinge to the colors; this type is not observed in *H. katherinæ,* but found in *H. magnificus.*

In degree of polarization, in character of the figure, and in appearance with selenite *H. andromeda* is closer to *H. katherinæ* than to *H. magnificus.*

Iodine Reactions.

With 0.25 Lugol's solution the grains color a moderate to light violet (value 47), slightly deeper but of about the same reddish tint as in *H. katherinæ,* but a little lighter and more reddish than in *H. magnificus;* the color deepens gradually, becoming bluer and to about the same depth and tint as in *H. katherinæ,* but a little

lighter and less bluish than in *H. magnificus.* With 0.125 Lugol's solution the grains color very light to light reddish violet, a little lighter but of about the same tint as in *H. katherinæ,* decidedly lighter and more reddish than in *H. magnificus;* the color deepens very little, less than in both parents. Both the quantitative and qualitative reactions with iodine of *H. andromeda* exhibit a closer relationship to *H. katherinæ* than to *H. magnificus.*

ANILINE REACTIONS.

With *gentian violet* the grains color very faintly at once, and in half an hour become moderate to deep (value 58), slightly lighter than in *H. katherinæ* and slightly deeper than in *H. magnificus.*

With *safranin* the grains color very faintly at once, and in half an hour become moderately deep to deep (value 58), a little lighter than in both parents.

In the reactions with aniline stains, *H. andromeda* shows a closer relationship to *H. katherinæ* than to *H. magnificus.*

TEMPERATURE REACTIONS.

The majority of the grains are gelatinized at 78.5° to 80° C., and all at 81° to 82° C., mean 81.5° C. The temperature of gelatinization is closer to *H. katherinæ* than to *H. magnificus.*

EFFECTS OF VARIOUS REAGENTS.

The reaction with *chloral hydrate* begins in a few in 1 minute. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 14 per cent of the grains and 20 per cent of the total starch in 15 minutes; in about 25 per cent of the grains and 29 per cent of the total starch in 30 minutes; in about 31 per cent of the grains and 35 per cent of the total starch in 45 minutes; in about 33 per cent of the grains and 47 per cent of the total starch in 60 minutes. (Chart D 85.)

A small bubble appears at the hilum and expands slightly more than in *H. katherinæ,* but not nearly so much as in *H. magnificus.* The lamellæ do not usually become more distinct, about as in *H. katherinæ,* slightly less than in *H. magnificus.* The entire grain becomes refractive and a border of greater refractivity is formed, as noted in both parents; this border broadens more quickly and is more prominent than in *H. katherinæ,* but is not so sharply defined as in *H. magnificus.* Gelatinization begins and proceeds as noted for both parents, most of the grains more closely follow the methods described in *H. katherinæ* than in *H. magnificus.* The distention and distortion of the capsules, as well as the appearance of refractive fragments and granules formed during the process of gelatinization, are as in both parents; such granules appear earlier in the process of more grains than in *H. katherinæ,* and about as in *H. magnificus.*

The gelatinized grains are swollen and distorted as in both parents. More grains unaffected by the reagent remain than in *H. katherinæ,* but considerably less than in *H. magnificus.* *H. andromeda* exhibits qualitatively a much closer relationship to *H. katherinæ* than to *H. magnificus.*

The reaction with *chromic acid* begins in rare grains in 1 minute. Complete gelatinization occurs in but rare grains and has begun in but few, less than 0.5 per cent of both the entire number of grains, and the total starch in 5 minutes; in less than 0.5 per cent of the grains and 8 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 25 per cent of the total starch in 30 minutes; in about 8 per cent of the grains and 90 per cent of the total starch in 45 minutes; in about 16 per cent of the grains and 95 per cent of the total starch in 60 minutes. (Chart D 86.)

The reaction with *pyrogallic acid* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 1 per cent of both the entire number of grains and total starch in 5 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 15 minutes; in about 7 per cent of the grains and 8 per cent of the total starch in 30 minutes; in about 8 per cent of the grains and 12 per cent of the total starch in 45 minutes; and in about 12 per cent of the grains and 26 per cent of the total starch in 60 minutes. (Chart D 87.)

The reaction with *nitric acid* begins in a few grains immediately. Complete gelatinization occurs in less than 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 10 per cent of the grains and 12 per cent of the total starch in 15 minutes; in about the same percentage of grains and 13 per cent of the total starch in 30 minutes; in about 14 per cent of the grains and 15 per cent of the total starch in 45 minutes; and in about the same percentage of grains and 20 per cent of the total starch in 60 minutes. (Chart D 88.)

The hilum swells and a small bubble which is often quite transient appears at the hilum. This bubble is not inclosed within an enlarged fissure, somewhat more frequently than in *H. katherinæ,* but less often than in *H. magnificus.* The grains become very refractive, the lamellæ rarely becoming refractive previous to gelatinization, and a refractive border separated by a distinct lamella from the main body of the grain only occasionally observed; the latter somewhat more frequent than in *H. katherinæ,* but not nearly so frequent as in *H. magnificus.* Fissures do not form so quickly in so many grains as in *H. katherinæ,* but they gradually may become deeper and more branched throughout the entire length of the fissures; this arrangement and depth of fissures being similar to that in *H. magnificus,* but much less frequently found. Gelatinization more frequently follows the course described in *H. katherinæ,* but in a very few grains the process may start in a refractive border which is narrower, but may exhibit both methods of gelatinization of the border, as has been described in *H. magnificus.*

The gelatinized grains are swollen and slightly to considerably distorted, a little more distortion being observed than in *H. katherinæ,* but not so much as in *H. magnificus.* Grains are occasionally observed in which a narrow border has become gelatinized, while the main body of the grain is but little affected; such grains were not observed in *H. katherinæ,* but much more frequently in *H. magnificus* than in *H. andromeda.* *H. andromeda,* excepting in a few grains, exhibits qualitatively a much closer relationship to *H. katherinæ* than to *H. magnificus.*

The reaction with *sulphuric acid* begins in a few grains in half a minute. Complete gelatinization occurs in about 8 per cent of the entire number of grains and

9 per cent of the total starch in 5 minutes; in about 35 per cent of the grains and 50 per cent of the total starch in 15 minutes; in about 67 per cent of the grains and 81 per cent of the total starch in 30 minutes; in about 73 per cent of the grains and 93 per cent of the total starch in 45 minutes; and in about 90 per cent of the grains and 98 per cent of the total starch in 60 minutes. The ungelatinized portion of the grains consists of a part of the outline of a few grains, together with rare grains that are unaffected. (Chart D 89.)

The reaction with *hydrochloric acid* begins at once. Complete gelatinization occurs in less than 3 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about the same in 15 minutes; in about 9 per cent of the grains and 11 per cent of the total starch in 30 minutes; in about 26 per cent of the grains and 30 per cent of the total starch in 45 minutes; and in about 28 per cent of the grains and 42 per cent of the total starch in 60 minutes. The ungelatinized starch is in the form of many entire grains and parts of the margins of others. (Chart D 90.)

The reaction with *potassium hydroxide* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 6 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 7 per cent of the total starch in 30 minutes; in about 5 per cent of the grains and 9 per cent of the total starch in 45 minutes; and in about 7 per cent of the grains and 11 per cent of the total starch in 60 minutes. (Chart D 91.)

The reaction with *potassium iodide* begins slowly. Complete gelatinization occurs in only rare grains and in less than 1 per cent of the total starch in 5 minutes; less than 1 per cent of the grains and over 1 per cent of the total starch in 15 minutes; and about 1 per cent of the grains and 2.5 per cent of the total starch in 30 minutes; in about the same percentage in 45 minutes; and in about the same percentage of grains and 3 per cent of the total starch in 60 minutes. (Chart D 92.)

The hilum and fissures react about the same as in *H. katherinæ*, the hilum swells less and enlargement of fissures is less frequent than in *H. magnificus*. The entire grain becomes very refractive and in most of the grains the definition of lamellæ and the refractive border is about the same as in *H. katherinæ*, but occasionally grains are found with one very prominent lamella forming a line of demarcation between the main body of the grain and the refractive border, which is so often found in *H. magnificus*. The fissures are usually delicate and much more like those of *H. katherinæ*, but in a few grains they are quite deep and much like those of *H. magnificus*. The course of gelatinization is even more varied than in both parents, while it more frequently starts as in *H. katherinæ*, yet in some grains the marginal border and main body of the grain react as noted in *H. magnificus*. The starch is sometimes disorganized with the appearance of refractive granules, more frequently than in *H. katherinæ* but much less frequently than in *H. magnificus*. The starch may be broken into refractive masses previous to gelatinization, as noted in *H. katherinæ*, but not observed in *H. magnificus*. The most resistant starch is more frequently located as described in *H. katherinæ*, though in a small number of grains it may occur as in *H. magnificus*.

The gelatinized grains are swollen and slightly to considerably distorted, about the same as in *H. katherinæ* but less than in *H. magnificus*. Some grains are only partially gelatinized, while many are but little affected beyond the swelling of the hilum and the enlargement of the fissures, much closer in this respect to *H. katherinæ* than to *H. magnificus*. Excepting in a few grains, *H. andromeda* exhibits qualitatively a much closer relationship to *H. katherinæ* than to *H. magnificus*.

The reaction with *potassium sulphocyanate* begins in very few grains in 1 minute. Complete gelatinization occurs in less than 1 per cent of the entire number of grains and of the total starch in 5 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 15 minutes; in about the same percentage of grains and 3.5 per cent of the total starch in 30 minutes; in about the same percentage of grains and 4 per cent of the total starch in 45 minutes; and in about 3.5 per cent of the grains and 4 per cent of the total starch in 60 minutes. (Chart D 93.)

The swelling of the hilum and the absence of a bubble are about the same as noted for both parents A delicate fissure, sometimes present in the untreated grain, often becomes a little deeper than in *H. katherinæ*, but much less enlarged and refractive than in *H. magnificus*. The lamellæ occasionally become more distinct, a little more frequently than in *H. katherinæ*, but with much less frequency than in *H. magnificus*. The methods of gelatinization described for both parents are observed, but many more grains follow those noted in *H. katherinæ* than in *H. magnificus*. The fissures more closely resemble those of *H. katherinæ* than of *H. magnificus*. The mesial region is more frequently disorganized with irregularly massed granules of somewhat greater refractivity than in *H. katherinæ*, but not so brilliant in so many grains as was found in *H. magnificus*. The fissures occasionally become very deep and sparingly branched, followed by the breaking of the starch into moderately large refractive fragments, not quite so frequently observed as in *H. katherinæ*, but with greater frequency than in *H. magnificus*.

The gelatinized grains are swollen and slightly to considerably distorted, greater distortion in a few more grains than in *H. katherinæ*, but in considerably less than *H. magnificus*. Many grains in which the reaction is almost complete contain a number of refractive granules, these are more frequently arranged in the same manner and located similarly to those observed in *H. katherinæ*, but a small number more closely follow the arrangement and location of those in *H. magnificus*. Excepting in a few grains, *H. andromeda* shows a much closer relationship to *H. katherinæ* than to *H. magnificus*.

The reaction with *potassium sulphide* begins in only rare grains in 1 minute. Complete gelatinization occurs in less than 1 per cent of the entire number of grains and of the total starch in 5 minutes; in about the same percentage of each in 15, 30, 45, and 60 minutes, respectively. (Chart D 94.) (Insufficient material to study the qualitative reactions.)

The reaction with *sodium hydroxide* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 1 per cent of the entire number of grains and the total starch in 5 minutes; in about the same percentage in 15 minutes; in about 1 per cent of the grains and 2.5 per cent of the total starch in 30 minutes; in about the same percentage of each in 45 minutes; and in about the same percentage of grains and 3 per cent of the total starch in 60 minutes. (Chart D 95.)

The reaction with *sodium sulphide* begins in rare grains in 1 minute. Complete gelatinization occurs in only rare grains and less than 0.5 per cent of the total starch in 5 minutes; in about the same in 15 minutes; in about the same percentage of grains and 1 per cent of the total starch in 30 minutes; in about the same percentage of grains and 2 per cent of the total starch in 45 minutes; and in about 1.5 per cent of the grains and 2.5 per cent of the total starch in 60 minutes. (Chart D 96.)

The reaction with *sodium salicylate* begins in half a minute. Complete gelatinization occurs in 40 per cent of the entire number of grains and 56 per cent of the total starch in 5 minutes; in about 97 per cent of the grains and 98 per cent of the total starch in 15 minutes; and in practically all of the starch in 30 minutes. (Chart D 97.)

A small bubble appears at the hilum, which is about the same as in *H. katherinæ,* but is less frequently found inclosed within an enlarged fissure, and less often expands to considerable size, than in *H. magnificus.* The lamellæ in the main body of the grain do not become more distinct, about the same as in *H. katherinæ,* but less distinct in some grains than in *H. magnificus.* A refractive border is formed, the definition of the separate lamellæ, as well as the entire border from the rest of the grain, is much more frequently about the same as in *H. katherinæ,* but in a very small number of grains the resemblance is close to *H. magnificus.* The methods of gelatinization are the same as observed in both parents. In most grains gelatinization follows the course described in *H. katherinæ;* but in rare grains, as in *H. magnificus,* the refractive border may become first very sharply defined and then suddenly gelatinized without distortion; and this is sometimes followed by complete solution of the capsule.

The gelatinized grains are swollen and distorted about the same as in *H. katherinæ,* but more distortion than in *H. magnificus.* Either partial or complete solution may follow the gelatinization of the grain, more rapid solution in parts of a few grains than in *H. katherinæ,* but in not nearly so many as in *H. magnificus.* With the exception of a few grains, *H. andromeda* shows qualitatively a much closer relationship to *H. katherinæ* than to *H. magnificus.*

The reaction with *calcium nitrate* begins in rare grains in 1 minute. Complete gelatinization has occurred in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 60 minutes. (Chart D 98.)

The reaction with *uranium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and the total starch in 60 minutes. (Chart D 99.)

The reaction with *strontium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and less than 0.5 per cent of the total starch in 5 minutes; in about the same percentage of grains and nearly 1 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and nearly 2 per cent of the total starch in 30 minutes; and in nearly 2 per cent of the grains and 2.5 per cent of the total starch in 45 and 60 minutes, respectively. (Chart D 100.)

The reaction with *cobalt nitrate* begins in very rare grains in 1 minute. Complete gelatinization was not observed in any grain among the entire number and the process has begun in but rare grains, much less than 0.5 per cent of both the entire number and the total starch, in 5 minutes; no apparent progress in 15 and 30 minutes; complete gelatinization occurs in rare grains, less than 0.5 per cent, and 0.5 per cent of the total starch in 45 minutes; about the same in 60 minutes. (Chart D 101.)

The reaction with *copper nitrate* begins in rare grains in 1 minute. Complete gelatinization was not observed and the reaction had begun in rare grains, much less than 0.5 per cent of both of the entire number of grains and of the total starch, in 5 minutes; very slight progress in 15, 30, 45, and 60 minutes, until at the end of this period complete gelatinization still occurs in but rare grains and the process has begun in but few grains, much less than 0.5 per cent of both the grains and the total starch gelatinized. (Chart D 102.) Gelatinization of the rare grains began at the distal end, accompanied by extension of the capsule. In those grains in which a fissure extends through the grain, and in which a proximal and a distal end are scarcely demonstrable, the process proceeds more rapidly at one end which presumably is the distal end.

The reaction with *cupric chloride* begins in very rare grains in 1 minute. Complete gelatinization was not observed in any grains and the reaction has begun in but rare grains, much less than 0.5 per cent of both the entire number of grains and the total starch, in 5 minutes; no apparent change in 15 minutes; complete gelatinization occurs in rare grains and has begun in but few grains in 30 minutes; slight progress in 45 minutes; complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 0.5 per cent of the total starch in 60 minutes. (Chart D 103.) Gelatinization is observed in very few grains, but in those affected the course more closely follows that noted in *H. katherinæ* than in *H. magnificus.*

The reaction with *barium chloride* begins in very rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 60 minutes. (Chart D 104.)

The reaction with *mercuric chloride* begins in very rare grains in 1 minute. No complete gelatinization in the entire number of grains was observed and the process was begun in but rare grains, much less than 0.5 per cent of both the entire number of grains and total starch in 5 minutes; complete gelatinization still observed in but very rare grains less than 0.5 per cent and about 0.5 per cent of total starch in 15 minutes; very little if any change in 30, 45, and 60 minutes, respectively. (Chart D 105.)

6. Starches of Hæmanthus katherinæ, H. puniceus, and H. König Albert.

H. katherinæ is described on pages 429 to 433.

Hæmanthus puniceus (Pollen Parent).

(Plate 4, fig. 20; Charts D 106 to D 126.)

Histologic Properties.

In *form* the majority of the grains are simple and isolated; many occur in aggregates of from 2 to at least 20 components, more frequently 9. Pressure facets are present in many grains. Compound grains are quite numerous, the number of components varying from 2 to at least 26, more often the former. The grains are very irregular and vary much in shape; only rarely are grains with perfectly regular outlines observed. The irregularities are chiefly due to the following causes: First, well-marked depressions, sometimes slightly concave on the surface which are not noticeable in *H. katherinæ;* second, to rounded protuberances, not so frequently observed in *H. katherinæ,* located usually near the proximal end; third, to a slight shifting of the longitudinal axis of primary lamellæ as in *H. katherinæ;* fourth, to an occasional secondary set of lamellæ, less often observed than in *H. katherinæ.* The arrangement of the components of the aggregates is very characteristic. They may be compactly clustered and have the form of simple grains, but frequently they are linearly arranged to be club-shaped. When the latter, the grains gradually enlarge at one end, or are root-shaped when branched, or are occasionally serpentine, etc. The conspicuous forms among the isolated grains are irregular, broadened ovoid; irregular pyriform; nearly round; imperfect ellipsoidal; bean-shaped; and plano-convex. There are in addition imperfect quadrangular with rounded angles, potato-shaped; heart-shaped; reniform; napiform; and some of indefinite forms. The grains are usually much flattened; and they are more flattened than those of *H. katherinæ.*

The *hilum* is not usually distinct in the large grains. When observed it is a round or flattened-elliptical, or lenticular, non-refractive spot, which varies from centric to 0.30 eccentric of the longitudinal axis, more often 0.40 to 0.45. The hilum in the small components of aggregates is a small, round, refractive spot which varies in position from centric to slightly eccentric. The hilum is more often demonstrable, and, on the whole, less eccentric than in *H. katherinæ.*

The *lamellæ* are not usually demonstrable throughout the entire grain. When observed directly around the hilum they form either circular or elliptical rings; but most of the lamellæ follow the outline of the grain. The lamellæ vary from fairly fine on the narrower grains to very delicate on the broadened ones, and frequently one coarse and more refractive lamella is located at about 0.33 of the distance from the hilum. On the large grains 20 to 28 lamellæ have been counted, and on the medium-sized grains 8 to 11.

The *size* varies from the smaller grains which are 4 by 3μ, to the larger which are 44 by 28μ, in length and breadth. The common size is 32 by 28μ. The grains tend to be broader in proportion to length than in *H. katherinæ.*

Polariscopic Properties.

The *figure* is centric to quite eccentric and fairly clean-cut and distinct, the lines are more distinct throughout entire figure in a larger number of grains than in *H. katherinæ.* The lines vary from rather narrow to very broad, and in the majority of the grains intersect obliquely; they are more often broad and intersect at right angles in more grains than in *H. katherinæ.* They may also be arranged in the form of a mesial line with bisected ends, as in the bean-type. The figure is often quite irregular because of the lines being frequently bent or bisected, the former about the same, but the latter more often, than in *H. katherinæ.* Double figures (in both compound and aggregates) are often present, much more frequently observed than in *H. katherinæ.*

The *degree of polarization* is high to very high (value 78), slightly higher than in *H. katherinæ.* It varies from moderate to very high with the majority moderately high, there is also a variation in the same aspect of a given grain. The variation in the different grains is about the same, but rather more in the same aspect of a given grain than in *H. katherinæ.*

With *selenite* the quadrants are moderately well defined in a majority of grains, rather less than in *H. katherinæ;* and they are often unequal in size and irregular in shape, but rather less than in *H. katherinæ.* The colors may be pure, but sometimes the blue and usually the yellow are not quite pure. The colors tend more often to be impure than in *H. katherinæ.*

Iodine Reactions.

With 0.25 Lugol's solution the grains color a moderate to light violet with a reddish tint (value 40) that gradually becomes quite deep tending to a blue-violet, a few taking on a deeper color than the others. The color is lighter but rather redder than in *H. katherinæ.* With 0.125 Lugol's solution, the grains color a light violet with reddish tint which very gradually becomes slightly deeper, not so deep but redder than *H. katherinæ.* After heating in water until the grains are gelatinized and then adding a 2 per cent Lugol's solution, the gelatinized *grains* color a bright rather light blue, some grains deeper than others, a little deeper and without the reddish tint sometimes found in *H. katherinæ;* the *solution* colors a deep indigo-blue, about the same as in *H. katherinæ.* If the gelatinized preparation is boiled for 2 minutes and then treated with an excess of iodine, the *grain-residues* color a light to deep dull blue, many with a reddish tint, more varied but not so reddish as in *H. katherinæ;* and the *capsules* color an old-rose to deep heliotrope, the latter not quite so reddish as in *H. katherinæ.*

Aniline Reactions.

With *gentian violet* the grains begin to color at once, and in half an hour they are moderately deep to deep, slightly deeper than in *H. katherinæ* (value 62).

With *safranin* the grains begin to stain immediately, and in half an hour they are moderately deep to deep, a little deeper than in *H. katherinæ* (value 62).

Temperature Reactions.

The majority of the grains are gelatinized at 77° to 70° C., and all at 81° to 82.5° C., mean 81.75° C. The smaller more slender grains, which are not very numerous, are the most resistant.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 8 per cent of the entire number of grains and 14 per cent of the total starch in 5 minutes; in about 50 per cent of the grains and 64 per cent of the total starch in 15 minutes; in about 66 per cent of the grains and 78 per cent of the total starch in 30 minutes; in about 70 per cent of the grains and 80 per cent of the total starch in 45 minutes; in about 72 per cent of the grains and 82 per cent of the total starch in 60 minutes. (Chart D 106.)

A bubble forms at the hilum and frequently expands to greater size but is less persistent than in *H. katherinæ.* The lamellæ do not become any more distinct. The grain becomes more refractive and a border of even greater refractivity is formed, as noted in *H. katherinæ,* but the border more quickly broadens than in *H. katherinæ.* Methods of gelatinization are sometimes observed that are similar to those in *H. katherinæ;* but in many grains the process spreads rapidly through the mesial region towards the margin, the proximal end of this border frequently proving the most resistant. In grains with somewhat abrupt corners, the process may start at several points on the margin and advance towards the hilar region. Refractive fragments or granules, as well as striation, may occur in the more resistant starch previous to gelatinization, but with much less frequency than in *H. katherinæ.*

The grains are swollen and somewhat to much distorted, the distortion being much less than in *H. katherinæ.* A number of grains are but little affected beyond the initial stages, a less number than in *H. katherinæ.*

The reaction with *chromic acid* begins in a few grains immediately. Complete gelatinization occurs in about 9 per cent of the entire number of grains and 27 per cent of the total starch in 5 minutes; in about 18 per cent of the grains and 78 per cent of the total starch in 15 minutes; in about 36 per cent of the grains and 87 per cent of the total starch in 30 minutes; in about 60 per cent of the grains and 97 per cent of the total starch in 45 minutes; in about 78 per cent of the grains and 99 per cent of the total starch in 60 minutes. (Chart D 107.)

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 33 per cent of the entire number of grains and 65 per cent of the total starch in 5 minutes; in about 83 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 90 per cent of the grains and 97 per cent of the total starch in 30 minutes; in about the same percentage of each in 45 minutes; and in about 93 per cent of the grains and over 99 per cent of the total starch in 60 minutes. At the end of an hour a few scattered grains have small parts of the margin ungelatinized. (Chart D 108.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 33 per cent of the entire number of grains and 60 per cent of the total starch in 5 minutes; in about 44 per cent of the grains and 75 per cent of the total starch in 15 minutes; in about 65 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 75 per cent of the grains and 95 per cent of the total starch in 45 minutes; and in about 78 per cent of the grains and 96 per cent of the total starch in 60 minutes. (Chart D 109.)

The hilum swells much more, accompanied by the evolution of a bubble, than in *H. katherinæ.* The lamellæ quickly become more distinct, and the mesial portion is rapidly gelatinized more frequently without the formation of fissures; this method not commonly observed in *H. katherinæ.* The scattered smaller grains gelatinize more slowly, and sharply defined fissures are present, which, however, are not so copiously branched as in *H. katherinæ.* The grain is disorganized into granules of similar arrangement, but much less refractive than in *H. katherinæ.* The gelatinized grains, as a rule, are somewhat distorted, more than in *H. katherinæ.*

The reaction with *sulphuric acid* begins immediately and many grains are gelatinized in 1 minute. Complete gelatinization occurs in about 80 per cent of the entire number of grains and 95 per cent of the total starch in 5 minutes; in about 90 per cent of the grains and 98 per cent of the total starch in 10 minutes; in about 94 per cent of the grains and 99 per cent of the total starch in 15 minutes. The ungelatinized starch is found in the margin of few grains, and minute parts may be seen after the lapse of 45 minutes. (Chart D 110.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 55 per cent of the entire number of grains and 80 per cent of the total starch in 5 minutes; in about 67 per cent of the grains and 91 per cent of the total starch in 15 minutes; in about 75 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about the same percentage of each in 45 minutes; and in the same percentage of grains and 97 per cent of the total starch in 60 minutes. The very small amount of ungelatinized starch is observed in the marginal part of many grains. (Chart D 111.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 48 per cent of the entire number of grains and 70 per cent of the total starch in 5 minutes; in about 50 per cent of the grains and 80 per cent of the total starch in 15 minutes; in about 80 per cent of the grains and 95 per cent of the total starch in 30 minutes; in 84 per cent of the grains and 97 per cent of the total starch in 45 minutes; and in 90 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 112.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 40 per cent of the entire number of grains and 52 per cent of the total starch in 5 minutes; in about 45 per cent of the grains and 58 per cent of the total starch in 15 minutes; in about 60 per cent of the grains and 67 per cent of the total starch in 30 minutes; in about 62 per cent of the grains and 80 per cent of the total starch in 45 minutes and in about 68 per cent of the grains and 92 per cent of the total starch in 60 minutes. (Chart D 113.)

The hilum swells in many more grains than in *H. katherinæ;* and the lamellæ become somewhat more distinct and striated, more so than in *H. katherinæ.* Fissures form which are delicate and usually short, but more sharply defined than in *H. katherinæ.* The mesial portion is disorganized in many grains forming slightly refractive granules, while in others there are refractive granules, with much greater variation of refractivity of the different grains than in *H. katherinæ.* The marginal lamellæ become sharply defined and striated, in

some grains breaking into refractive linear granules, in others gelatinized without breaking into granules, while in others the lamellæ near the margin are broken into linear granules, but the outermost two or three are gelatinized without the previous appearance of granules; more varied in this respect than in *H. katherinæ*.

The gelatinized grains are swollen, but very little distorted, slightly more than in the few completely gelatinized grains found in *H. katherinæ;* they usually resemble the untreated grain in shape, as in *H. katherinæ*.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 54 per cent of the entire number of grains and in about 72 per cent of the total starch in 5 minutes; in about 69 per cent of the grains and 84 per cent of the total starch in 15 minutes; in about 73 per cent of the grains and 89 per cent of the total starch in 30 minutes; in about the same percentage of each in 45 minutes; and in about 75 per cent of the grains and 90 per cent of the total starch in 60 minutes. A few of the smaller grains, especially the mesial part, and the margin of some of the larger grains, are ungelatinized. (Chart D 114.)

The hilum swells more than in *H. katherinæ*, but fissures proceeding from it are shorter and less clearly defined. The lamellæ for about one-third to one-half the distance from the hilum become well defined, and the definition sharper and present in many more grains than in *H. katherinæ*. The lamellæ of the mesial portion are quickly broken down into a mass of fairly refractive granules which are soon completely gelatinized, less refractive and less resistant than in *H. katherinæ*. The marginal lamellæ are frequently undemonstrable and may gelatinize without breaking into linear granules, although in some grains definition and striation are followed by disorganization into linear granules; these granules are much less common than in *H. katherinæ*. In the more resistant slender grains the marginal lamellæ of the proximal end may become sharply differentiated and striated followed by breaking into linear granules; and in the scattered smaller grains which are the most resistant, the fissures are more sharply defined, and the mesial and marginal granules are about as in *H. katherinæ*.

The gelatinized grains are swollen and considerably distorted, the latter decidedly more than in *H. katherinæ*. Most of the grains do not resemble the form of the untreated grain.

The reaction with *potassium sulphide* begins immediately and several grains are gelatinized in 1 minute. Complete gelatinization occurs in about 15 per cent of the entire number of grains and 45 per cent of the total starch in 5 minutes; in about 40 per cent of the grains and 60 per cent of the total starch in 15 minutes; in about 52 per cent of the grains and 66 per cent of the total starch in 30 minutes; in about the same percentage of each in 45 minutes; and in about the same percentage of grains and 70 per cent of the total starch in 60 minutes. (Chart D 115.)

The hilum swells much more rapidly, and the fissures proceeding from it are much less sharply defined than in *H. katherinæ*. The lamellæ often become more distinct within the mesial region, as well as the sharply defined lamella which cuts off a narrow refractive border; distinct over more of the grain than in *H. katherinæ*. The mesial portion of the grain is frequently broken down without forming granules or a few that are slightly to quite refractive, much less refractive than in *H. katherinæ*. A single row of brilliant linear granules is sometimes noted a short distance within a very narrow refractive border, this border being differentiated into a few sharply defined lamellæ which gelatinize without breaking into granules; such grains were not observed in *H. katherinæ*. In some grains, notably the smaller ones, the marginal lamellæ are broken down into linearly arranged granules as in *H. katherinæ*.

The gelatinized grains are much swollen and considerably distorted, more so than in *H. katherinæ*. The larger, more numerous grains are usually completely gelatinized, but in the smaller grains either linear granules around the margin or a refractive border may resist gelatinization; much more completely gelatinized than in *H. katherinæ*.

The reaction with *sodium hydroxide* begins immediately and a few grains are gelatinized in 1 minute. Complete gelatinization occurs in about 44 per cent of the entire number of grains and 61 per cent of the total starch in 5 minutes; in about 50 per cent of the grains and 67 per cent of the total starch in 15 minutes; in about 54 per cent of the grains and 73 per cent of the total starch in 30 minutes; in about 60 per cent of the grains and 80 per cent of the total starch in 45 minutes; and in about 63 per cent of the grains and 84 per cent of the total starch in 60 minutes. (Chart D 116.)

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 42 per cent of the entire number of grains and 50 per cent of the total starch in 5 minutes; in about 45 per cent of the grains and 54 per cent of the total starch in 15 minutes; in about the same percentage of each in 30 minutes; in about 57 per cent of the total starch in 45 minutes; and in about 48 per cent of the grains and 60 per cent of the total starch in 60 minutes. (Chart D 117.)

The reaction with *sodium salicylate* begins in 30 seconds. Complete gelatinization occurs in about 54 per cent of the entire number of grains and in about 60 per cent of the total starch in 5 minutes; in about 94 per cent of the grains and 96 per cent of the total starch in 15 minutes; in about 98 per cent of the grains and over 99 per cent of the total starch in 20 minutes; and in all of the starch in 25 minutes. (Chart D 118.)

A bubble appears at the hilum and expands to much greater size in many grains and is more transient than in *H. katherinæ*. The lamellæ gradually become distinct in many grains, much sharper than in *H. katherinæ*. A refractive border is formed in which the lamellæ become well defined previous to gelatinization; this border is much more sharply defined from the body of the grain and is broader around the entire grain than in *H. katherinæ*. The methods of gelatinization are even more varied than in *H. katherinæ*. The process proceeds in some grains as described for *H. katherinæ*, but in other grains the lamellæ forming the refractive border become very sharply defined, followed by sudden gelatinization of this border with the exception of a very narrow outer border at either side of the hilum which resists for a short time; in such grains the main body of the grain is the

most resistant; a fissure passing through the hilum as the bubble is expelled often precedes gelatinization of this mesial mass of starch.

The gelatinized grains are swollen and distorted, and either partial or complete solution of the grain may follow gelatinization as noted in *H. katherinæ*.

The reaction with *calcium nitrate* begins in some of the grains immediately. Complete gelatinization occurs in about 34 per cent of the entire number of grains and 50 per cent of the total starch in 5 minutes; in about the same percentage of grains and 57 per cent of the total starch in 15 minutes; in about the same percentage of grains and 60 per cent of the total starch in 30 minutes; in about 38 per cent of the grains and 62 per cent of the total starch in 45 minutes; and in about the same percentage of each in 60 minutes. (Chart D 119.)

The reaction with *uranium nitrate* begins immediately. Complete gelatinization occurs in about 22 per cent of the entire number of grains and 26 per cent of the total starch in 5 minutes; in about 26 per cent of the grains and 30 per cent of the total starch in 15 minutes; in about 32 per cent of the grains and 35 per cent of the total starch in 30 minutes; in about the same percentage of each in 45 and 60 minutes, respectively. (Chart D 120.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 28 per cent of the entire number of grains and 44 per cent of the total starch in 5 minutes; in about 30 per cent of the grains and 50 per cent of the total starch in 15 minutes; in about 42 per cent of the grains and 60 per cent of the total starch in 30 minutes; in about 46 per cent of the grains and 68 per cent of the total starch in 45 minutes; and in about 60 per cent of the grains and 78 per cent of the total starch in 60 minutes. (Chart D 121.)

The reaction with *cobalt nitrate* begins immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 7 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 10 per cent of the total starch in 30 minutes; in about 6 per cent of the grains and 12 per cent of the total starch in 45 minutes; in about 8 per cent of the grains and 14 per cent of the total starch in 60 minutes. (Chart D 122.)

The reaction with *copper nitrate* begins immediately. Complete gelatinization begins in about 5 per cent of the entire number of grains and 11 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 14 per cent of the total starch in 15 minutes; in about 9 per cent of the grains and 15 per cent of the total starch in 30 minutes; in about 11 per cent of the grains and 16 per cent of the total starch in 45 minutes; in about 16 per cent of the grains and 24 per cent of the total starch in 60 minutes. (Chart D 123.) Gelatinization proceeds rapidly through the mesial portion of the grain, the entire border being the most resistant; this gradually becomes gelatinized, when complete gelatinization occurs.

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 16 per cent of the entire number of grains and 37 per cent of the total starch in 5 minutes; in about 28 per cent of the grains and 53 per cent of the total starch in 15 minutes; slight progress in 30 minutes; in about 31 per cent of the grains and 56 per cent of the total starch in 45 minutes; in about 37 per cent of the grains and 59 per cent of the total starch in 60 minutes. (Chart D 124.)

Gelatinization proceeds rapidly through the mesial portion, well-defined fissures not being observed in the grains more quickly gelatinized. The entire margin is the more resistant for a short period, but finally in many grains the distal margin is more quickly gelatinized than the interior. The much more rapid gelatinization of the distal margin than of the inclosed portion, with extension of the capsule, was not observed in this starch, as was noted in some grains of *H. katherinæ*.

The reaction with *barium chloride* begins in rare grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 1.5 per cent of the total starch in 5 minutes; in about 1.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 6 per cent of the total starch in 30 minutes; and in about the same percentage of each in 45 and 60 minutes, respectively. (Chart D 125.)

The reaction with *mercuric chloride* begins immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in about 5.5 per cent of the grains and 15 per cent of the total starch in 15 minutes; in about 9 per cent of the grains and 17 per cent of the total starch in 30 minutes; in about 17 per cent of the grains and 20 per cent of the total starch in 45 minutes; little if any further progress or about 22 per cent of the total starch in 60 minutes. (Chart D 126.)

Hæmanthus König Albert (Hybrid).

(Plate 4, fig. 21; Charts D 106 to D 126.)

Histologic Properties.

In *form* the majority of the grains are simple and isolated. Many occur in aggregates of from 2 to 20 or more components, most frequently from 2 to 9. Pressure facets are present on many of the grains. Compound grains are often noted, the number of components varying from 2 to at least 20, commonly of the former number. The grains are very irregular and vary much in shape, more so than in either parent. The irregularities are due chiefly to the same causes as noted under *H. katherinæ* and *H. puniceus*, but one or more well-marked depressions are frequently found on the surface of the grain, absent in *H. katherinæ* but present in *H. puniceus;* and the protuberances and secondary sets of lamellæ are not so frequently observed as in *H. katherinæ*, but about the same as in *H. puniceus*. The arrangements of the components of the aggregates are even more varied than in *H. puniceus*. In addition to those of linear arrangement noted for this species, T-shaped, boot-shaped, and sickle-shaped forms were observed. The conspicuous forms among the isolated grains are the same as those noted under *H. katherinæ* and *H. puniceus;* the lenticular forms are very rare; and the T-shaped, boot-shaped, club-shaped, and napiform grains proved in many instances to be aggregates. Such forms seen in *H. katherinæ* might also have been found to be aggregates had it not proved impossible to satisfactorily dem-

onstrate the presence of the hilum and the lamellæ in these grains. Since forms of grains of both parents are present in the hybrid, the grains vary more in shape than in either parent. The majority are of a more broadened type than in *H. katherinæ,* standing nearer in this feature to those of *H. puniceus.* The majority of the grains are much flattened, being more flattened than in *H. katherinæ,* but there are not so many grains that are much flattened as in *H. puniceus.* On the whole, the alliance is closer to *H. puniceus.*

The *hilum* is usually not distinct in the large grains. When observed it is a round, flattened-elliptical, or lenticular, non-refractive spot which varies from centric to 0.25 eccentric, commonly 0.35 to 0.45, of the longitudinal axis. The hilum in the components of aggregates is a small, round, refractive spot; centric to slightly eccentric. It is not so refractive as in *H. puniceus.* The hilum is more often demonstrable than in *H. katherinæ,* but not so frequently as in *H. puniceus.* As regard peculiarities of the hilum, the grains are closer to those of *H. puniceus.*

The *lamellæ* are frequently not demonstrable, they are about the same as in *H. katherinæ,* but more indistinct than in *H. puniceus.* When observed near the hilum, they follow the outline of this structure, and are moderately fine to very fine, circular, elliptical, or lenticular rings. Most of the lamellæ follow the outline of the grains. Rarely one rather coarse and more refractive lamella may be observed at about one-third of the distance from the hilum. On the more slender grains of medium size 8 to 12, and on the larger broadened forms about 20, lamellæ may be counted. The peculiarities of the lamellæ place the grains in closer relationship to *H. puniceus.*

The *size* of the grains varies from the smaller which are 4 by 2μ, to the larger which are usually about 38 by 24μ, rarely 52 by 28μ, in length and breadth. The common size is 28 by 20μ. In size the grains are closer to those of *H. puniceus.*

Polariscopic Properties.

The *figure* is centric to quite eccentric and moderately clean-cut and distinct, the lines are more distinct throughout the entire figure in more grains than in *H. katherinæ,* but in about the same as in *H. puniceus.* The character and arrangement of the lines are the same as in *H. katherinæ* and *H. puniceus,* but there are more grains in which they are broad and cross at right angles than in *H. katherinæ,* but slightly less than in *H. puniceus.* Double figures are much more frequently observed than in *H. katherinæ* and about the same as in *H. puniceus.*

The *degree of polarization* is high to very high (value 80), higher than in either parent, but nearer to *H. puniceus.* The same variation in the different grains as well as in the same aspect of a given grain is the same as in the parent, but the variation in the same aspect of a given grain is usually greater than in *H. katherinæ,* and about the same as in *H. puniceus.*

With *selenite* the quadrants are moderately well defined, in a majority of grains rather less than in *H. katherinæ,* but about the same as in *H. puniceus.* They are quite irregular in shape and unequal in size, less than in *H. katherinæ,* but rather more than in *H. puniceus.* The colors are rather more often impure than in *H. katherinæ,* and the yellow about the same, but the blue not so often impure as in *H. puniceus.* In polariscopic properties the grains bear a closer resemblance to those of *H. puniceus.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains color a moderate to light reddish violet (value 43) which gradually becomes a quite deep violet with bluer tint, not quite so deep as in *H. katherinæ,* but deeper than in *H. puniceus,* and with rather more of a reddish tint than in either parent. With 0.125 per cent Lugol's solution the grains color a light violet with reddish tint which gradually becomes slightly deeper. At first the color is about the same as in case of the starches of the parents, but it does not become as deep nor as blue as *H. katherinæ,* yet it is somewhat deeper than in *H. puniceus.* After heating in water, until the grains are gelatinized, and then adding 2 per cent Lugol's solution the starch solution colors a deep indigo-blue, and the gelatinized grains a rather light blue, some deeper than others, and a few large ones taking on a reddish tint. There is a greater variety in the depth of color, but the average is considerably deeper than in *H. katherinæ,* and about the same, but the color is not so pure as in *H. puniceus.* If the gelatinized preparation is boiled for 2 minutes, and then treated with an excess of iodine, the *grain-residues* color a moderately light to moderately deep blue with reddish tint, and the *capsules* a light old-rose, deep heliotrope to wine-red. The *grain-residues* and the *capsules* are more varied in color, but the averages are deeper than in both *H. katherinæ* and *H. puniceus.* Both quantitative and qualitative reactions with iodine exhibit a closer relationship to *H. katherinæ* than to *H. puniceus.*

Aniline Reactions.

With *gentian violet* the grains begin to stain at once, and in half an hour they are colored moderate to deep (value 58). The color is lighter than in either *H. katherinæ* or *H. puniceus.*

With *safranin* the grains color at once, and in half an hour they are moderate to deep in color, lighter than in either *H. katherinæ* or *H. puniceus* (value 58). In the reactions with aniline stains *H. könig albert* shows a closer relationship to *H. katherinæ* than to *H. puniceus.*

Temperature Reactions.

The majority of the grains are gelatinized at 80° to 82° C., and all at 82.5° to 84° C., mean 83.25° C. The temperature of gelatinization is very uneven in this starch, practically all the larger broadened grains are gelatinized at 77° to 79° C., but the smaller narrower forms are resistant until 80° to 82° C. is reached, hence the temperature of gelatinization for the majority is at the latter point. The temperature of gelatinization of *H. könig albert* is closer to *H. katherinæ* than to *H. puniceus.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 16 per cent of the grains and 18 per cent of the total starch in 15 minutes; in about 33 per cent of the grains and

39 per cent of the total starch in 30 minutes; in about 39 per cent of the grains and 53 per cent of the total starch in 45 minutes; in about 44 per cent of the grains and 61 per cent of the grains in 60 minutes. (Chart D 106.)

At the hilum a bubble forms which expands slightly more in many grains than in *H. katherinæ*, but not as much as in *H. puniceus*. The lamellæ do not become any more distinct, as noted for both parents. The grain becomes more refractive and a border of greater refractivity is formed as noted for both parents; it broadens more quickly than in *H. katherinæ*, scarcely so much in so many grains as in *H. puniceus*. The same methods of gelatinization are observed as noted in both parents; a larger number follow the course of the process in *H. katherinæ*, yet gelatinization starting in the mesial region and at two or more points is sometimes found, as is more commonly present in *H. puniceus*. Refractive fragments and granules sometimes form previous to complete gelatinization, not quite so frequently observed as in *H. katherinæ* but with decidedly more frequency than in *H. puniceus*.

The gelatinized grains are swollen and distorted about as in *H. katherinæ*, but more distorted than in *H. puniceus*. A larger number of grains have not advanced beyond the initial stages than in both parents. The qualitative reactions, excepting in a few grains, exhibit a much closer relationship to those observed in *H. katherinæ*.

The reaction with *chromic acid* begins in a few grains in 1 minute. Complete gelatinization occurs in but few grains and has begun in but few, less than 0.5 per cent, of both the entire number of grains and the total starch in 5 minutes; in less than 0.5 per cent of the grains and 19 per cent of the total starch in 15 minutes; in about 22 per cent of the grains and 46 per cent of the total starch in 30 minutes; in about 25 per cent of the grains and 93 per cent of the total starch in 45 minutes; in about 44 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 107.)

The reaction with *pyrogallic acid* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 9 per cent of the grains and 11 per cent of the total starch in 30 minutes; in about 18 per cent of the grains and 25 per cent of the total starch in 45 minutes; and in about 22 per cent of the grains and 33 per cent of the total starch in 60 minutes. (Chart D 108.)

The reaction with *nitric acid* begins very slowly and even at the end of 5 minutes there are no obvious signs of gelatinization. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 2.5 per cent of the total starch in 15 minutes; in about 9 per cent of the grains and 11 per cent of the total starch in 30 minutes; in about 10 per cent of the grains and 14 per cent of the total starch in 45 minutes; and in about 15 per cent of the grains and 22 per cent of the total starch in 60 minutes. (Chart D 109.)

The hilum swells, a bubble appearing more frequently than in *H. katherinæ*, but not nearly so frequently as in *H. puniceus*. The lamellæ are not usually distinct, but the grains become very refractive, about as in *H. katherinæ*, while lamellæ are less often distinct than in *H. puniceus;* the mesial portion is usually gelatinized without the formation of definite much-branched fissures, and is disorganized frequently with but slightly refractive granules, being more refractive in the most-resistant grains; the fissures appear with much less frequency, and the granules are less refractive, than in *H. katherinæ;* fissures appear with somewhat more frequency and more grains disorganize with more refractive granules than in *H. puniceus*. No grains were observed in which gelatinization first appeared at the distal margin accompanied with a clear swelling, this method not infrequently appearing in *H. katherinæ*, but not present in *H. puniceus*. The gelatinized grains are slightly distorted, somewhat less than in *H. katherinæ*, but more than in *H. puniceus*. Many grains are affected by the reagent but still contain many granules at the end of 60 minutes, but not so numerous, refractive, or frequent as in *H. katherinæ*, yet much more frequent than in *H. puniceus*. In this reaction *H. könig albert* shows qualitatively a somewhat closer relationship to *H. katherinæ* than to *H. puniceus*.

The reaction with *sulphuric acid* begins in a few grains in 1 minute. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 25 per cent of the grains and 50 per cent of the total starch in 15 minutes; in about 67 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 81 per cent of the grains and 95 per cent of the total starch in 45 minutes; and in 90 per cent of the grains and 99 per cent of the total starch in 60 minutes. (Chart D 110.) At the end of 60 minutes only small marginal parts of a few grains remain ungelatinized. The grains become extremely refractive, and when observed in the polariscope the lowering polarization indicates an internal disorganization, inasmuch as there is no apparent external alteration, as in *H. katherinæ*.

The reaction with *hydrochloric acid* begins in a few grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the total starch in 5 minutes; in about 12 per cent of the total starch, chiefly entire grains, in 15 minutes; in about 24 per cent of the grains and 54 per cent of the total starch in 30 minutes; in about 29 per cent of the grains and 62 per cent of the total starch in 45 minutes; and in about the same percentage of grains and 67 per cent of the total starch in 60 minutes. (Chart D 111.)

The reaction with *potassium hydroxide* begins in rare grains in 30 seconds. Complete gelatinization occurs in less than 1 per cent of the entire number of grains and 0.5 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about the same percentage of the grains and total starch in 30 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 45 minutes; and in about 3 per cent of the grains and 4 per cent of the total starch in 60 minutes. (Chart D 112.)

The reaction with *potassium iodide* begins at once in only rare grains. Complete gelatinization occurs in less than 1 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about the same

percentage of each in 30 and 45 minutes, respectively; and in about 1 per cent of the grains and 1.5 per cent of the total starch in 60 minutes. (Chart D 113.) While these grains with rare exception do not become gelatinized they become more refractive when viewed in ordinary light and less polariscopic when viewed between crossed nickols, indicating molecular changes.

The hilum swells more in a larger number of grains than in *H. katherinæ*, but not in nearly so many as in *H. puniceus*. No special change was noted in the definition of the lamellæ. Fissures form of similar character to those of both parents, they are slightly more prominent than in *H. katherinæ*, but less than in *H. puniceus*. The mesial and marginal regions of the grain are disorganized with the appearance of granules that have about the same refractivity and arrangement as in *H. katherinæ;* much less varied in the few grains gelatinized than in *H. puniceus*.

The gelatinized grains are swollen, but very little distorted, about as in *H. katherinæ*, slightly less than in *H. puniceus*. They resemble the untreated grain in form, as in both parents. In this reaction *H. könig albert* shows qualitatively much closer relationship to *H. katherinæ* than to *H. puniceus*.

The reaction with *potassium sulphocyanate* begins in very few grains in 1 minute. Complete gelatinization occurs in less than 1 per cent of the entire number of grains and total starch in 5 minutes; in about 1 per cent of the grains and 2.5 per cent of the total starch in 15 minutes; in over 2.5 per cent of the grains and 3.5 per cent of the total starch in 30 minutes; in about the same percentage of each in 45 minutes; and in about the same percentage of grains and 4 per cent of the total starch in 60 minutes. (Chart D 114.) About 97 per cent of the entire number of grains are apparently unaffected.

The hilum swells more, and the lamellæ near the hilum become more sharply defined in more grains than in *H. katherinæ*, but neither as markedly in nearly so many grains as in *H. puniceus*. The fissures which proceed from the hilum are scarcely so well defined as in *H. katherinæ*, but deeper in many more grains than in *H. puniceus*. The mesial and marginal regions are broken into granules, and sometimes into moderately large fragments of about the same refractivity and arrangement, but less resistancy, than in *H. katherinæ*, but they are more refractive and the marginal granules much more frequently have a linear arrangement and are much more resistant than in *H. puniceus*.

The gelatinized grains are swollen, a little more distorted, and much more frequently with all the granules gelatinized than in *H. katherinæ;* not quite as distorted and more frequently with refractive granules than in *H. puniceus*. In the reaction *H. könig albert* shows qualitatively a much closer relationship to *H. katherinæ* than to *H. puniceus*.

The reaction with *potassium sulphide* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 1 per cent of the entire number of grains and total starch in 5 minutes; in a slightly larger percentage of each in 15 minutes; and in about 2 per cent of each in 30, 45, and 60 minutes, respectively. (Chart D 115.)

The hilum swells a little more rapidly than in *H. katherinæ*, but much less than in *H. puniceus;* and the fissures proceeding from it are a little less sharply defined than in *H. katherinæ*, but more than in *H. puniceus*. The single lamella is less sharply defined, but becomes more distinct in the region nearer the hilum than in *H. katherinæ;* but is not distinct near the hilum in nearly so many grains as in *H. puniceus*. The mesial portion of the grain is disorganized into very slightly to quite refractive granules, the mean being less refractive than in *H. katherinæ*, but more than in *H. puniceus*. The marginal border is usually broken down into linear granules, as in *H. katherinæ*, and more frequently than in *H. puniceus*.

The gelatinized grains are much swollen and slightly distorted, a little more than in *H. katherinæ*, but considerably less than in *H. puniceus*. Scarcely so many grains are found with the outermost lamella ungelatinized as in *H. katherinæ*, but many more than in *H. puniceus*. The gelatinized grains bear some resemblance to the untreated grain, a little less number than in *H. katherinæ*, but many more than in *H. puniceus*. In this reaction *H. könig albert* shows qualitatively a much closer relationship to *H. katherinæ* than to *H. puniceus*.

The reaction with *sodium hydroxide* begins in very few grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about the same in 15 and 30 minutes, respectively; in about 0.5 per cent of the grains and 1.5 per cent of the total starch in 45 minutes; and in about 1 per cent of the grains and 2 per cent of the total starch in 60 minutes. (Chart D 116.)

The reaction with *sodium sulphide* begins in rare grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and in about 2 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 2.5 per cent of the total starch in 15 minutes; in about the same percentage of each in 30, 45, and 60 minutes, respectively. Apart from the very few grains that are quickly affected by the reagent there is extremely little evidence of reaction. (Chart D 117.)

The reaction with *sodium salicylate* begins in 30 seconds. Complete gelatinization occurs in about 50 per cent of the entire number of grains and 65 per cent of the total starch in 5 minutes; in about 94 per cent of the grains and 97 per cent of the total starch in 15 minutes; and 98 per cent of the grains and over 99 per cent of the total starch in 30 minutes. (Chart D 118.) Rare grains may resist gelatinization for 40 minutes.

A small bubble appears at the hilum which is very persistent and expands little if any previous to expulsion; about the same as in *H. katherinæ*, but is more persistent and expands less than in *H. puniceus*. The lack of definition in the lamellæ and the appearance of the refractive border are about the same as *H. katherinæ*, but less sharply defined than in *H. puniceus*. Gelatinization begins and proceeds in many more grains in about the same manner as in *H. katherinæ*, but in a few the process closely follows *H. puniceus*.

The gelatinized grains are swollen and distorted so that they do not resemble the untreated grains as in both parents. Either partial or complete solution may follow the gelatinization of the grains as in both parents. In this reaction, excepting in a few grains, *H. könig albert*

shows qualitatively much closer relationship to *H. katherinæ* than to *H. puniceus.*

The reaction with *calcium nitrate* begins in very rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; and in about the same percentage of each in 15, 30, 45, and 60 minutes, respectively. (Chart D 119.)

The reaction with *uranium nitrate* begins in very rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; and in about the same percentage of each in 15, 30, 45, and 60 minutes, respectively. (Chart D 120.)

The reaction with *strontium nitrate* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about the same percentage of each in 15 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 30 minutes; in about 1 per cent of the grains and 1.5 per cent of the total starch in 45 minutes; and in about the same percentage of each in 60 minutes. (Chart D 121.)

The reaction with *cobalt nitrate* begins in very rare grains in 1 minute. Complete gelatinization was not observed in any grain among the entire number and the process has begun in rare grains much less than 0.5 per cent of both the entire number of grains and the total starch, in 5 minutes; no special progress noted in 15 minutes; slight progress, complete gelatinization in very rare grains, still less than 0.5 per cent, and 0.5 per cent of the total starch in 30 minutes; about the same in both 45 and 60 minutes, respectively. (Chart D 122.)

The reaction with *copper nitrate* begins in very rare grains in 1 minute. Complete gelatinization was not observed and the reaction has begun in but rare grains, much less than 0.5 per cent of both the entire number of grains and the total starch in 5 minutes; very slight progress in 15, 30, 45, and 60 minutes, even less than 0.5 per cent of both the entire number of grains and the total starch are gelatinized at the end of this period. (Chart D 123.)

Gelatinization has begun and proceeded in so few grains that a definite type is scarcely defined, but in those noted the process proceeds through the mesial portion along the course of fissures.

The reaction with *cupric chloride* begins in very rare grains in 2 minutes. Complete gelatinization was not observed in any grains and the process has begun in very rare grains, much less than 0.5 per cent of both the grain and the total starch, in 5 minutes; very slight progress in 15 minutes; complete gelatinization occurs in very rare grains and the process has still begun in but rare grains in 30 minutes; about the same in 45 and 60 minutes, at the end of which period much less than 0.5 per cent of both the grains and the total starch is gelatinized. The reaction has made still less progress than in *H. katherinæ.* (Chart D 124.)

Very few grains show much effect from treatment with the reagent, but when observed gelatinization proceeds through the mesial region as in both parents, the more rapid gelatinization with extension of the capsule as noted in *H. katherinæ* was not observed.

The reaction with *barium chloride* begins in rare grains in 1 minute. Complete gelatinization is not observed in any grains but about 0.5 per cent of the total starch is disorganized. Little progress occurs in 15, 30, 45, and 60 minutes, respectively. (Chart D 125.) A few more grains are affected, but gelatinization progresses less far than in *H. katherinæ*, there being complete gelatinization of less than 0.5 per cent of the grains and total starch in 60 minutes.

The reaction with *mercuric chloride* begins in rare grains in 1 minute. Complete gelatinization of entire grains was not observed, and the process has begun in much less than 0.5 per cent of the entire number of grains and total starch in 5 minutes. There was no apparent progress in 15, 30, 45, and 60 minutes, there still being much less than 0.5 per cent of both the entire number of grains and total starch in 60 minutes. (Chart D 126.)

4. CRINUM.

The members of this genus are large bulbous plants that are natives of tropical and semi-tropical countries and widely cultivated as garden and green-house plants, especially in the old world. The genus is closely allied to *Amaryllis, Ammocharis, Brunsvigia, Nerine,* and *Strumaria.* Baker (Amaryllideæ, page 74) describes 79 species, 13 of which are natives of tropical America, but only one is a native of the United States (*C. americanum* Linn., popularly known as the Florida Swamp Lily). He divides them into three sub-genera—*Stenaster, Platyaster,* and *Codoncrinum.* There are said to be only two hardy species—*C. moorei* Hook. (*C. makoyanam* Carr., *C. colensoi* Hort., *C. mackenii* Hort., and *C. natalense* Hort.) and *C. longifolium* Thumb. (*C. capense* Herb., *C. riparium* Herb., *Amaryllis longifolia* Linn., *Amaryllis capensis* Miller), the former being the less hardy.

The crinums are very readily hybridized, and a large number of hybrids have been reported abroad and in this country. The principal species used were *C. longifolium, C. asiaticum, C. erubescens, C. zeylanicum, C. scabrum,* and *C. americanum,* particularly the first, and also as the seed parent. The only one of these hybrids that seems to be generally known is *C. powellii* Hort.

Three sets of parent-stock and hybrid-stock, all belonging to the subgenus *Codonocrinum,* were studied in this research:

7. *C. moorei* Hook., *C. zeylanicum* Linn. (*C. herbertianum* Wall., *C. wallichianum* Roem., *C. ornatum* var. *zeylanicum* and var. *Herbertianum* Herb., *Amaryllis zeylanica* Linn., *Amaryllis ornata*) and the hybrid *C. hybridum j. c. harvey.* The specimen of *C. moorei* was obtained from F. H. Krelage & Son, Haarlem, Holland; that of *C. zeylanicum* from Theodore L. Mead, Oviedo, Florida; and that of the hybrid from the grower, Reasoner Brothers, Oneco, Florida.
8. *C. zeylanicum, C. longifolium,* and the hybrid *C. kircape.* The specimen of *C. longifolium* was obtained from E. H. Krelage & Son, and those of *C. zeylanicum* and *C. kircape* from Thomas L. Mead, Oviedo, Florida, a grower of the hybrid.
9. *C. longifolium, C. moorei,* and the hybrid *C. powellii.* The specimens of the parent-stocks and hybrid-stock were obtained from E. H. Krelage & Son.

7. Starches of Crinum moorei, C. zeylanicum, and C. hybridum J. C. Harvey.

Crinum moorei (Seed Parent).

(Plates 4 and 5, figs. 22 and 29; Charts D 127 to D 147.)

Histologic Properties.

In *form* the majority of the grains are simple and isolated with the exception of a few which appear in aggregates of from 2 to 4, usually 2 or 3, components. Compound grains are fairly numerous, and consist of from 2 to 3 components. No well-defined pressure facets are observed. The surface of the grain is often irregular, owing chiefly to: (1) The presence of one or more usually small, rounded protuberances which are generally located at or near the proximal end, where they are occasionally quite large and sometimes blunt; (2) to the shifting of the longitudinal axis of the primary lamellæ; to a secondary set of lamellæ placed usually at right angles or inclosing the primary set; (3) to slight depressions of the curved side line, occasionally becoming concave at the distal end; (4) to a lateral curvature at the proximal end; (5) to a sinuous outline at the distal margin or sometimes at one side of mussel-shell-shaped grains; and (6) to the abrupt deflection of elongated slender grains at or just distal to the slightly eccentric hilum. The conspicuous forms of the simple grains are elongated-ovoid-shaped which are often squared at the distal end, mussel-shell-shaped, oyster-shell-shaped, pyriform, and club-shaped. The additional forms are slipper-shaped, rod-shaped, finger-shaped, elongated and ordinary clam-shell-shaped, somewhat diamond-shaped, boot-shaped, and nearly round. The conspicuous forms of the compound grains are grains which consist of 2 or 3 small components which are usually located with their long axes transversely to the long axis of the grain, often with a broadened proximal end and inclosed in common lamellæ. Sometimes the components are located with their long axes longitudinal. There are ellipsoidal and somewhat heart-shaped grains which consist of 2 components of medium size surrounded by a few common lamellæ. Compound grains occasionally appear which consist of 3 components of medium size, linearly arranged and surrounded by a few common lamellæ. Rarely a large mussel-shell-shaped grain may be observed, with a deep crescentic cleft towards one corner of the distal margin outlining one large and one fairly small component, the latter being located at the distal corner. The smaller component is sometimes subdivided into two by a delicate diagonal fissure. The narrow elongated grains are not flattened, but the broadened forms, such as the oyster-shell-, mussel-shell-, and clam-shell-shaped grains, are flattened so that when viewed on edge they are ellipsoidal, sometimes with squared distal end, or ovoid with a pointed distal end.

The *hilum* is a small, round, oval, or lenticular refractive spot, and occasionally there may be 2 or 3, rarely 4, such hila either transversely or longitudinally arranged. A small rounded cavity is sometimes found at the hilum, and rarely one or more fissures. There may be one short, transverse or diagonal fissure, the former sometimes passing through only the distal margin of the hilum; or fissures may be arranged in soaring-bird and cruciate figures; or rarely one short, delicate, ragged fissure passes longitudinally from the hilum. The range of eccentricity is from 0.45 to 0.10, commonly about 0.20 to 0.15, of the longitudinal axis.

The majority of the *lamellæ* are from fairly fine to very fine, and when demonstrable they usually form circular or oval rings directly around the hilum, but tend to have the shape of the outline of the grain when even a short distance outward. The lamellæ are generally demonstrable throughout the entire grain, but they are usually very fine and less distinct near the hilum. Often when about one-third distalward they become less fine and very distinct, and sometimes they are slightly refractive when located near the distal margin. One coarse, very refractive lamella is frequently found that is located at varying distances from the hilum; and often groups of fine lamellæ, varying from 2 to 6 according to the shape and size of the grain, may be separated by less fine and refractive lamellæ. A band of 2 or 3 fairly coarse refractive lamellæ is occasionally found about the middle or nearer the distal margin; or a still broader band of such lamellæ may be observed at the latter region, and separated from the main body of the grain by a very coarse, refractive lamella. Secondary lamellæ are slightly refractive, and usually less fine and often more irregular in outline, than those of the primary set. The number of lamellæ in the primary set of the large grains varies from 54 to 64.

The *size* varies from the smaller which are 3 by 2μ, to the larger which are 60 by 38μ, rarely 80 by 52μ, in length and breadth. The common size is about 48 by 28μ.

Polariscopic Properties.

The *figure* is slightly to very eccentric, distinct, and clear-cut. The lines are usually fine and intersect obliquely. They are more often straight, but frequently bent and bisected. Double figures are somewhat numerous.

The *degree of polarization* is high to very high (value 85). It varies in different grains, a few having a moderately high and a few having an extremely high polarization, the majority being high to very high. Moderate variation in polarization in the same aspect of a given grain is often present.

With *selenite* the quadrants are usually well defined, unequal in size, and often irregular in shape. The colors are generally pure, the yellow less often pure than the blue. Some of the grains have a greenish tinge.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains color a moderate blue-violet (value 50), which rapidly becomes fairly deep to deep, the bluish tint increasing. With 0.125 per cent solution the grains color a very light violet which deepens somewhat rapidly becoming more blue, the depth varying from moderate to deep, the deeper the color the more the blue. After heating in water until the grains are gelatinized, and then adding a 2 per cent Lugol's solution, the *grains* color a moderate to a moderately deep indigo-blue, a few with a reddish tint; the *capsules* color a heliotrope to an old-rose; and the *solution* a moderately deep indigo-blue. If the preparation is boiled for two minutes, and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* color a very light blue with reddish tint; the *capsules* a light old-rose to a wine-red, with more of the capsules of the latter color; and the *solution* a deep indigo-blue.

Aniline Reactions.

With gentian violet the grains color lightly at once, and in half an hour most of them are colored moderately deep, the grade being moderate to deep (value 65). There is frequently some inequality in the coloration of a grain, the main body tending usually to stain more deeply than a band of lamellæ at the distal margin and the secondary sets of lamellæ (rarely the reverse is found in the latter). In a few grains a narrow band of deeper color is located near the distal end. The differences in depth of color are, however, not marked.

With *safranin* the grains color moderately at once, and in half an hour the color is moderate to deep (value 65). The same unevenness in coloration of the grain as that noted with gentian violet is found in this reaction.

Temperature Reactions.

The majority of the grains are gelatinized at 68° to 71° C., and all but rare resistant grains at 70° to 71° C., mean 70.5° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 31 per cent of the entire number of grains and 31 per cent of the total starch in 5 minutes; in about 38 per cent of the grains and 45 per cent of the total starch in 15 minutes; in about 51 per cent of the grains and 58 per cent of the total starch in 30 minutes; in about 72 per cent of the grains and 79 per cent of the starch in 45 minutes; in about 79 per cent of the grains and 89 per cent of the total starch in 60 minutes. (Chart D 127.)

A bubble appears at the hilum. It is not, as a rule, located in a cleft, is quite persistent, and is usually small until just previous to the gelatinization of the area surrounding the hilum. The lamellæ do not, as a rule, become more distinct, although in some grains their definition is sharper, especially previous to disorganization. A refractive border at the distal margin is quickly formed around the entire grain. Gelatinization begins at the distal margin, but may quickly follow at the proximal end and the process is accompanied by much distention and distortion of the capsule. The definition of the lamellæ forming the refractive border usually becomes sharp, and sometimes clefts appear between them previous to gelatinization. In the most resistant grains the process of gelatinization proceeds from the distal margin to the proximal end, a narrow band at the proximal end and sides proving the most resistant, but when the process advances from both ends an area distal to the hilum is the most resistant.

The gelatinized grains are much swollen and usually much distorted so that they do not resemble the form of the untreated grain. At the end of the reaction a few grains remain which are but little affected by the reagent, and others in which varying amounts of the starch are ungelatinized (generally found at the proximal end) in the area surrounding the hilum, the bubble at this point being persistent in such grains. The bubble in some way appears to repel the invasion of reagent.

The reaction with *chromic acid* begins in a few grains in a half minute. Complete gelatinization occurs in about 35 per cent of the entire number of grains and in 50 per cent of the total starch in 5 minutes; in about 50 per cent of the grains and 85 per cent of the total starch in 15 minutes; in about 99 per cent of the total starch in 25 minutes; and in all in 30 minutes. (Chart D 128.)

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 75 per cent of the total starch in 1 minute; in about 98 per cent in 2 minutes; in all but parts of rare grains in 3 minutes; and in all in 5 minutes. (Chart D 129.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 57 per cent of the entire number of grains and 80 per cent of the total starch in 1 minute; in about 67 per cent of the grains and 95 per cent of the total starch in 3 minutes; in about 86 per cent of the grains and 97 per cent of the total starch in 5 minutes; and in about 95 per cent of the grains and 99 per cent of the total starch in 10 minutes. About 1 per cent of the total starch (located in the proximal end of a few grains) remains at the end of 15 minutes, and some of this persists even after 60 minutes. (Chart D 130.)

The lamellæ become very sharply defined and striated through the mesial region of the grain, followed quickly by the disorganization of this portion with the appearance of but slightly refractive granules; the distal margin in many grains being gelatinized with lateral distention and considerable fluting. In a small percentage of grains a narrow border at the distal margin, and rarely around the entire grain, becomes more rapidly gelatinized than the central region. The gelatinized grains are much distorted and do not resemble the untreated grains.

The reaction with *sulphuric acid* begins immediately, and a few of the grains are fully gelatinized in 15 seconds. Complete gelatinization occurs in at least 75 per cent of the entire number of grains and nearly all the remainder are affected in 1 minute; about 98 per cent are gelatinized in 2 minutes; and all of the starch excepting traces at one end has been changed, making 99 per cent of the total starch gelatinized in 3 minutes. Complete gelatinization has occurred in 4 minutes. (Chart D 131.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 50 per cent of the entire number of grains and 75 per cent of the total starch in half a minute; in about 90 per cent of the total starch in 1 minute; in about 85 per cent of the grains and 97 per cent of the total starch in 2 minutes; and in about 99 per cent of the total starch in 5 minutes. A trace of ungelatinized starch may be observed in the proximal end of the grains at the end of 15 minutes. (Chart D 132.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 60 per cent of the entire number of grains and 94 per cent of the total starch in 1 minute; in about 82 per cent of the grains and 97 per cent of the total starch in 3 minutes; in about 87 per cent of the grains and 98 per cent of the total starch in 5 minutes; in about 88 per cent of the grains and 99 per cent of the total starch in 10 minutes; and in about 94 per cent of the grains and 99 per cent of the total starch in 15 minutes. The 1 per cent of starch ungelatinized is observed in the proximal end of about 6 per cent of the grains, and is relatively very resistant. (Chart D 133.)

The reaction with *potassium iodide* begins immediately and a few grains are gelatinized in half a minute. Complete gelatinization in about 68 per cent of the entire number of grains and 95 per cent of the total starch in 5 minutes; in about 93 per cent of the grains and 98 per cent of the total starch in 15 minutes; and in about 97 per cent of the grains and 99 per cent of the total starch in 30 minutes. The proximal end and sides nearby and scattered smaller grains are the most resistant. At the end of 60 minutes nearly 1 per cent of resistant starch remains. (Chart D 134.)

A bubble appears at the hilum. The lamellæ through the mesial portion from the hilum to the distal margin immediately become sharply defined and striated. A refractive narrow band in which the lamellæ gradually become demonstrable remains at the proximal end and sides. One or two plume-like fissures pass from the hilum to the distal margin, and also to the proximal end when an elongation is found at this region. The mesial portion is quickly disorganized into irregularly arranged fairly to quite refractive granules, the latter being located in the area around the hilum. The lamellæ near the distal margin, and very gradually those in the band at the proximal end and sides, are broken into linearly arranged granules. A distal band in a few grains is quickly gelatinized, without the appearance of granules, gelatinization being accompanied by much folding, imparting to the grain the appearance of a ruffle at the end of an ungelatinized part. Later the reaction involves the entire grain. The gelatinized grains are swollen, yet most of them are but very little distorted and accordingly bear some resemblance to the untreated grain. The grains are rarely completely gelatinized. A narrow band of either striated and sharply differentiated lamellæ or linearly arranged granules usually remains at the proximal end and sides, rarely around the entire margin.

The reaction with *potassium sulphocyanate* begins immediately. Several grains are fully gelatinized in half a minute. Complete gelatinization occurs in about 75 per cent of the entire number of grains, including a few scattered small grains, and 95 per cent of the total starch in 3 minutes; in about 85 per cent of the grains and 97 per cent of the total starch in 5 minutes; in about 92 per cent of the grains and 99 per cent of the total starch in 10 minutes; and in about 97 per cent of the grains, and in all but traces of starch in the proximal ends of some of the grains in 30 minutes. (Chart D 135.)

The hilum swells and a bubble forms which expands very little and is then expelled. Much-branched fissures pass from the hilum toward the distal margin, and gelatinization usually proceeds along their course. The lamellæ become very sharply defined and striated through the mesial portion, especially when two longitudinal or oblique fissures are formed. The starch is quickly broken down with the appearance of fairly refractive irregularly placed granules. The lamellæ of a marginal border in some grains become very sharply defined, and is often followed by the gelatinization of this area previous to that of the rest of the grain. A narrow refractive border at the proximal end and sides is the most resistant. The lamellæ forming this border become sharply defined and striated, but they do not usually break into linearly arranged granules previous to gelatinization. The gelatinized grains are swollen and distorted, the distortion being especially marked at the distal end. They are so distorted as not to resemble the untreated grain.

The reaction with *potassium sulphide* begins in a few grains in 1 minute. Complete gelatinization occurs in about 30 per cent of the entire number of grains and 54 per cent of the total starch in 5 minutes; in about 36 per cent of the grains and 62 per cent of the total starch in 15 minutes; in about 42 per cent of the grains and 70 per cent of the total starch in 30 minutes; in about the same percentage of grains and 78 per cent of the total starch in 45 minutes; and in about 45 per cent of the grains and 81 per cent of the total starch in 60 minutes. (Chart D 136.)

A bubble appears at the hilum and is generally expelled previous to much expansion. The lamellæ become very sharply defined and striated through the mesial region from the hilum to the distal margin, a narrow border at the proximal end and sides being very refractive and quite gradually becoming differentiated into lamellæ. One or two fissures are quickly formed which extend from the hilum toward the distal margin, and also toward the proximal end when protuberances occur at this point. These fissures are much branched and plume-like. When a distal narrow border is separated from the main body of the grain by a prominent lamella, a separate set of fissures may radiate from this lamella, through the border to the distal margin. Gelatinization usually spreads quickly through the mesial portion to the distal margin, but it may begin either at the distal border accompanied by distortion which imparts a ruffled appearance to this border, or when a protuberance is prominent it may start at this point or quickly follow the process in the mesial portion. In most grains, however, a narrow band at the proximal end and sides is the most resistant. The mesial portion is gelatinized sometimes without the appearance of refractive granules, but frequently fairly refractive granules appear in clusters along the course of the fissures. The distal border is occasionally gelatinized without the appearance of granules, but often one to several rows of linear granules appear. Sometimes a single row of granules may be seen at one or more points in the mesial portion, the granulation resulting from the disorganization of scattered and more refractive lamellæ that frequently occur in the grains of this species. The gelatinized grains are much swollen and considerably distorted, especially at the distal margin, though the distortion is not so great in this reaction as in many others. Occasionally a narrow striated band remains at the proximal end. The gelatinized grains are so distorted as not to resemble the untreated grain.

The reaction with *sodium hydroxide* begins immediately and within 1 minute many grains are wholly gelatinized. Complete gelatinization occurs in about 64 per cent of the entire number of grains and 90 per cent of the total starch in 3 minutes; in about 80 per cent of the grains and 97 per cent of the total starch in 5 minutes; and in about 98 per cent of the grains and 99 per cent of the total starch in 10 minutes. Only traces of ungelatinized starch remain in rare grains at the end of 15 minutes. (Chart D 137.)

The reaction with *sodium sulphide* begins immediately and a few grains are gelatinized in 1 minute.

Complete gelatinization occurs in about 59 per cent of the entire number of grains and 90 per cent of total starch in 5 minutes; in about 82 per cent of the grains and 97 per cent of the total starch in 15 minutes; in about 95 per cent of the grains and more than 99 per cent of the total starch in 30 minutes; and in all of the starch, except occasional traces in the proximal end, in 45 minutes. The proximal end and sides of the larger grains, and including more of the margin of some of the smaller grains, constitute the most resistant portions. (Chart D 138.)

A bubble usually appears at the hilum and, as a rule, does not expand much and is quickly expelled. The lamellæ become more distinct and striated through the mesial region from the hilum to the distal margin; a refractive border composed of lamellæ that are generally sharply defined may appear at the distal margin; a refractive border at the proximal end and sides is not differentiated into lamellæ, but is profusely striated. One or two fissures extend from the hilum to either the distal margin or corners, which fissures are branched and not very deep, and their definition is soon lost. The mesial region is quickly disorganized, frequently without and sometimes with the appearance of refractive granules. This breaking down of the lamellæ may proceed to the distal margin in many grains, but in a fair proportion of grains a few lamellæ at the distal margin are the first to become disorganized, without the appearance of granules and accompanied by considerable distortion. The refractive border at the proximal end and sides is the most resistant, and while deeply striated it finally becomes gelatinized without breaking into refractive granules. The gelatinized grains are so much swollen and distorted that they bear no resemblance to the untreated grain.

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 59 per cent of the entire number of grains and 61 per cent of the total starch in 5 minutes; in about 95 per cent of the grains and 98 per cent of the total starch in 15 minutes; in about 99 per cent of the grains and over 99 per cent of the total starch in 25 minutes; and in all in 30 minutes. (Chart D 139.)

A bubble appears at the hilum and is not, as a rule, inclosed within a fissure at this point; this bubble usually expands very little and is very persistent. The lamellæ in a moderately broad border at the distal margin often become temporarily sharply defined, this border gradually becomes very refractive, accompanied by loss of definition of the lamellæ, and it may extend proximalwards as a narrow border on the sides, occasionally even surrounding the entire grain. This border is frequently separated from the rest of the grain by very brilliant lamellæ. Gelatinization generally first begins at the distal margin and proceeds for some distance proximalward, the process then often starts at the proximal end. In such grains the most resistant area is a comparatively broad band probably about one-third of the length of the grain, just distal to the hilum. In some grains gelatinization proceeds gradually from the distal to the proximal end, a narrow band at the proximal end and sides nearby proving the most resistant starch. The starch is gelatinized without the appearance of fissures or of refractive granules. The gelatinized grains are much swollen and distorted so that they do not resemble the form of the untreated grain.

The reaction of *calcium nitrate* begins in some of the grains immediately. Complete gelatinization occurs in about 30 per cent of the entire number of grains and 78 per cent of the total starch in 5 minutes; in about 54 per cent of the grains and 85 per cent of the total starch in 15 minutes; in about the same number of grains but 90 per cent of the total starch in 30 minutes; in about the same as in the preceding observation in 45 minutes; and in about 55 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 140.)

The reaction with *uranium nitrate* begins in some of the grains immediately. Complete gelatinization occurs in about 38 per cent of the entire number of grains and 80 per cent of the total starch in 5 minutes; in about 51 per cent of grains and 84 per cent of the total starch in 15 minutes; in about 52 per cent of the grains and 86 per cent of the total starch in 30 minutes; in about 58 per cent of the grains and 89 per cent of the total starch in 45 minutes; and in about 60 per cent of the grains and 95 per cent of the total starch in 60 minutes. (Chart D 141.)

The reaction with *strontium nitrate* begins in 1 minute. Complete gelatinization occurs in about 43 per cent of the entire number of grains and 82 per cent of the total starch in 5 minutes; in about 65 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 82 per cent of the grains and over 97 per cent of the total starch in 30 minutes, and in about the same percentage of each as in the last observation at the end of 30 minutes; and in about 92 per cent of the grains and over 99 per cent of the total starch in 60 minutes. (Chart D 142.)

The reaction with *cobalt nitrate* begins immediately. Complete gelatinization occurs in about 9 per cent of the entire number of grains and 52 per cent of the total starch in 5 minutes; in about 30 per cent of the grains and 67 per cent of the total starch in 15 minutes; in about 37 per cent of the grains and 74 per cent of the total starch in 30 minutes; in about 42 per cent of the grains and 79 per cent of the total starch in 45 minutes; and in about the same percentage of each as in the last observation in 60 minutes. (Chart D 143.)

Gelatinization begins, as a rule, in a narrow border at the distal margin and later extends through the mesial portion of the grain; the proximal end and a narrow border on each side extending almost to the distal margin being very resistant.

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 24 per cent of the entire number of grains and 66 per cent of the total starch in 5 minutes; in about 33 per cent of the grains and 72 per cent of the total starch in 15 minutes; in about 45 per cent of the grains and 81 per cent of the total starch in 30 minutes; in about 50 per cent of the grains and 84 per cent of the total starch in 45 minutes; in about the same percentage of the grains with but slight progress in the total starch or about 87 per cent of the latter, in 60 minutes. (Chart D 144.)

In many grains gelatinization extends across the distal margin, accompanied by a ruffling of the capsule, and then progresses proximally through the mesial por-

tion. In some grains the ruffling of the capsule is absent and the process proceeds along fissures through the mesial region, the distal margin and the mesial portion always proving the least resistant. The extension and ruffling of the distal margin is much more frequently observed than in *C. longifolium*.

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 15 per cent of the entire number of grains and 54 per cent of the total starch in 5 minutes; in about 30 per cent of the grains and 66 per cent of the total starch in 15 minutes; in about 33 per cent of the grains and 72 per cent of the total starch in 30 minutes; in about 35 per cent of the grains and 77 per cent of the total starch in 45 minutes; in about 50 per cent of the grains and 81 per cent of the total starch in 60 minutes. (Chart D 145.)

In many grains gelatinization proceeds through the mesial region along the course of well-defined fissures, while in others it may begin at the distal margin. This process at the distal margin is generally accompanied with extension and frilling of the capsule more frequently in *C. moorei* than in *C. longifolium*. In a number of grains the proximal end and a narrow lateral border, which extends almost to the distal margin, are very resistant; this area is resistant in a greater proportion of grains than in *C. moorei* and in *C. longifolium*.

The reaction with *barium chloride* begins in a few grains immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 6.5 per cent of the grains and 10 per cent of the total starch in 15 minutes; in about 9.5 per cent of the grains and 16 per cent of the total starch in 30 minutes; in about 14 per cent of the grains and 21 per cent of the total starch in 45 minutes; and in about the same percentage of each as in the last observation in 60 minutes. (Chart D 146.)

The reaction with *mercuric chloride* begins immediately. Complete gelatinization occurs in about 16 per cent of the entire number of grains and 58 per cent of the total starch in 5 minutes; in about 37 per cent of the grains and 73.5 per cent of the total starch in 15 minutes; in about 42 per cent of the grains and 79 per cent of the total starch in 30 minutes; in 46 per cent of the grains and 83 per cent of the total starch in 45 minutes; and in about 47 per cent of the grains and 85 per cent of the total starch in 60 minutes. (Chart D 147.)

The clefts at the hilum and fissures proceeding therefrom become much enlarged and more refractive. These changes disappear more quickly than in *C. longifolium*. The proximal end and sides are more resistant in a larger number of grains than in *C. longifolium*, but there is a larger number of grains in process of gelatinization.

CRINUM ZEYLANICUM (POLLEN PARENT).

(Plates 4 and 5, figs. 23 and 25; Charts D 127 to D 147.)

HISTOLOGIC PROPERTIES.

In *form* the majority of the grains are simple, and they are isolated with the exception of a few which appear in aggregates of usually 2, rarely 3, components. Compound grains are fairly numerous and consist of from 2 to 3 components, a somewhat smaller proportion being found than in *C. moorei*. Well-defined pressure facets are not observed. The grains are sometimes irregular in outline, although not so much so, nor are so many grains irregular, as in *C. moorei*. The irregularities are due chiefly to the same causes as noted under *C. moorei;* but the quite large blunt protuberances at the proximal end, the curvature at the proximal end, and the abrupt deflection near the slightly eccentric hilum were not observed as in *C. moorei*. The conspicuous forms of the simple grains are ovoid (sometimes squared at the distal end), pyriform, triangular with curved sides and rounded angles. and clam-shell-shaped. The additional forms are mussel-shell-shaped, high dome-shaped, elongated ovoid, nearly round, and irregularly diamond-shaped. The conspicuous forms of the compound grains are medium-sized ellipsoidal and somewhat heart-shaped, composed of 2 equal-sized components that are separated by a deep cleft and surrounded by a few common lamellæ; a large mussel-shell-shaped grain with a deep crescentric cleft located near one corner of the distal margin, separating one large and one fairly small component that is located at the distal corner (a type of grain much more frequent in this species than in *C. moorei*); and a large ovoid grain with a deep crescentric cleft near the distal end that separates the 2 components, as in the preceding. Rarely, 2 small components may be located at the hilum of a grain similar in shape to the simple grains, and this form is much less frequently observed than in *C. moorei;* or 3 or 4 fairly small components may be linearly arranged and inclosed by a few common lamellæ, the components being smaller and less sharply divided and outlined than in *C. moorei*. The compound grains are not quite so numerous as in *C. moorei*. The majority of the grains are more broadened and flattened than in *C. moorei*, and when viewed on edge, while they have the same general form, a larger proportion are ovoid and with a more-pointed distal end.

The *hilum* is generally fissured. It may be observed as a round, oval, or lenticular spot as in *C. moorei*, but slightly less refractive. Multiple hila of the same number and arrangement may be observed as in *C. moorei*, but they are much less frequently seen. The small rounded cavity at the hilum, as well as the fissures, are of the same characters as those of *C. moorei*, but the former is much less frequent, and the fissures are very much more numerous and deeper than in *C. moorei*, and a fissure of the dragon-fly figure may be observed. A longitudinal fissure, rarely observed in *C. moorei*, is usually present, and is much longer, deeper, and branched, so that it is root-like; and rarely 2 similar root-like slightly divergent fissures are observed. The range of eccentricity is from 0.35 to 0.15, commonly 0.20 to 0.15, of the longitudinal axis, varying somewhat more, but on an average about the same distance, as in *C. moorei*.

The *lamellæ* are not usually demonstrable throughout the entire grain, but when apparent the majority are from fairly fine to very fine. When located near the hilum they form rings similar to those noted in *C. moorei*, and the majority tend as in *C. moorei* to follow the outline of the grain. The lamellæ usually are not present on an area one-third to two-thirds distalward from the hilum, and when discernible they are finer in this region than in the area toward the distal end, as in *C. moorei*. One coarse, very refractive lamella, which is located at varying distances from the hilum, is even

more prominent (possibly on account of indistinctness of most of the lamellæ) and present in a larger number of grains, than in *C. moorei*. Often 2, sometimes 3, very coarse, refractive lamellæ are seen, between which fine lamellæ are grouped. The occasional bands of fairly coarse, refractive lamellæ, located as in *C. moorei*, are observed more often than in *C. moorei*, especially at the distal margin. Such a band at the distal margin of the clam-shell-shaped grains is frequently bounded on both sides by very coarse, refractive, and wavy lamellæ, while in *C. moorei* these lamellæ may be observed only on the side toward the main body of grain. Grains having a secondary set of lamellæ placed at varying angles to the primary set are very rarely observed and therefore less numerous than in *C. moorei*. The number of lamellæ in the primary set of large grains was found to vary from 48 to 54, but these grains of this species are deeply fissured at the hilum, and the lamellæ so indistinct in this region that the actual number is uncertain. The number is less than in *C. moorei*.

The *size* varies from the smaller which are 6 by 5μ, to the larger which are 68 by 56μ, in length and breadth. There is less variation in size among the large grains than in *C. moorei*. The common size is about 50 by 38μ, distinctly larger than in *C. moorei*.

Polariscopic Properties.

The *figure* is eccentric, but with less variation in position than in *C. moorei;* it is distinct and clear cut. The lines are fairly fine, but not so fine in the majority of the grains as in *C. moorei;* and they are more often straight with a broadening towards the margin and less frequently bent and bisected than in *C. moorei*. Double figures are not quite so numerous as in *C. moorei*.

The *degree of polarization* is very high (value 93). Polarization in many grains is extremely high, but in the majority it is very high. The mean is much higher than in *C. moorei*. Variation is often present in the same aspect of a grain, but it is little less than in *C. moorei*.

With *selenite* the quadrants are well defined, unequal in size, and sometimes irregular in shape, but usually much more regular than in *C. moorei*. The colors are usually pure, more often than in *C. moorei*, but there is a larger number of grains having a greenish tinge.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains color a light to moderate blue-violet (value 35), lighter and less bluish than in *C. moorei*. The color deepens somewhat rapidly to a moderately deep blue-violet, but does not become so deep or so blue as in *C. moorei*, and there is more variation in depth of color of the different grains. With a 0.125 per cent Lugol's solution the grains color very light, lighter and more reddish in tone than in *C. moorei*. In the majority the color deepens somewhat rapidly to a fair violet while others remain very light, the color being lighter, more reddish, and more uneven in depth in the different grains than in *C. moorei*. After heating in water, until the grains are gelatinized, and then adding 2 per cent Lugol's solution, the majority of the *grains* color a fairly deep and a few a deep blue, very rarely with a reddish tint, the shade of blue being a little deeper and more often apparently free from red than in *C. moorei*. An occasional *capsule* is found of an old-rose or a heliotrope color. The *solution* colors a deep indigo-blue, a little deeper than in *C. moorei*. If the preparation is boiled for a few minutes and then treated with an excess of 0.2 per cent Lugol's solution, most of the *grain-residues* are colored a moderately light blue, a few moderately deep blue (some with reddish tint), but deeper and of a less reddish tint than in *C. moorei*. The *capsules* are colored a deep old-rose, a deep heliotrope, or a wine-red, but there are not so many of the last as there are in *C. moorei*.

Aniline Reactions.

With *gentian violet* the grains color moderately at once, deeper than in *C. moorei*. In half an hour the color is moderately deep to deep (value 67) with more grains of the latter than in *C. moorei*, hence the average coloration is a little deeper. A delicate band of deep color at or near the distal margin is often found on the less-colored grains, and it is much more prominent and appears in many more grains than in *C. moorei*. Rarely the main body of the grain stains more deeply than the band at the distal margin when the latter is composed of very refractive lamellæ, as is common in *C. moorei*. The very rare sets of secondary lamellæ are colored more deeply than the primary set, the reverse being more common in *C. moorei*. The contrast in depth of color of the main body of the grains with band of deep color is much greater than in *C. moorei*.

With *safranin* the grains react lightly at once, and in half an hour the color is moderately deep to deep (value 67). The variations in depth are somewhat greater, and there is a larger proportion of deeply colored grains than in *C. moorei*, thus making the mean coloration a little deeper. The unevenness of coloration in the grains which have bands and secondary lamellæ of deeper color is the same as with gentian violet, but the difference in depth is not so great. In comparison with *C. moorei*, the reaction is the same as with gentian violet.

Temperature Reactions.

The majority of the grains are gelatinized at 77° to 78° C., and all but rare resistant grains at 79° to 80° C., mean 79.5° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in but rare grains in 2 minutes. Complete gelatinization was not observed and less than 0.5 per cent of the total starch is gelatinized in 5 minutes. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 15 minutes; in about 1 per cent of the grains, and 3 per cent of the total starch in 30 minutes; and in about 3 per cent of the grains and 5 per cent of the total starch in 45 minutes. Little if any further change occurs in 60 minutes. (Chart D 127.)

The cleft at the hilum which is present in most of the grains becomes much enlarged and very refractive. In a few grains a small bubble appears which is not inclosed within a fissure. The refractive enlarged fissure is much more frequently seen than in *C. moorei*. The lamellæ do not usually become more distinct at once, even less so than in *C. moorei*. A refractive border is formed as in *C. moorei*, but it generally becomes broader at the distal margin previous to gelatinization than in *C. moorei*.

Gelatinization begins at the distal margin and proceeds proximalwards, the proximal end being resistant in many more grains than in *C. moorei*. The process is accompanied by distention and distortion of the capsule, but the distention is much less rapid than in *C. moorei*. The sharper definition of the lamellæ and the appearance of clefts may be observed in the refractive border at the distal margin previous to gelatinization, although with much less frequency than in *C. moorei*.

The gelatinized grains are swollen and considerably distorted, especially at the distal margin, but they are less distorted than in *C. moorei*. At the end of the reaction (60 minutes) most of the grains have not advanced beyond the early stages of the process; the cleft at the hilum remaining much enlarged and very refractive.

The reaction with *chromic acid* begins in a few grains in 1 minute. Complete gelatinization is observed in rare grains, all are penetrated by deep fissures, and less than 1 per cent of the total starch is gelatinized in 5 minutes. Only rare grains and only about 2 per cent of the total starch are gelatinized in 15 minutes. Only rare grains and the mesial portions of all others and about 70 per cent of the total starch are gelatinized in 30 minutes. About 50 per cent of the entire number of grains, considerable portions of the other grains, and about 94 per cent of the total starch are gelatinized in 45 minutes. More than 99 per cent of the total starch has been gelatinized in 60 minutes, the very small amount remaining ungelatinized is found in parts of the margin of scattered grains. (Chart D 128.)

The reaction with *pyrogallic acid* begins slowly, and complete gelatinization occurs in only 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 15 per cent of the total starch in 15 minutes; in about 45 per cent of the grains and 80 per cent of the total starch in 30 minutes (13 per cent of the grains being unaffected); in about 55 per cent of the grains and 88 per cent of the total starch in 45 minutes (about 10 per cent of the grains being but little affected); and in about 65 per cent of the grains and 92 per cent of the total starch in 60 minutes (about 8 per cent of the grains remaining but little affected). (Chart D 129.)

The reaction with *nitric acid* begins in very few grains in 2 minutes. Complete gelatinization occurs in only rare grains and in about 1 per cent of the total starch in 5 minutes; in about 1 per cent of the entire number of grains and 0.5 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 2 per cent of the starch in 45 minutes; and in about the same number of grains and 4 per cent of the total starch in 60 minutes. (Chart D 130.)

Gelatinization frequently begins along the distal margin and may proceed for a short distance at the sides nearby, accompanied by distention and fluting of the capsule which appears as a delicate ruffle on a bordering ungelatinized part of the grain. The main body of the grain is disorganized along the course of the much-branched fissures, accompanied by the breaking down of the mesial region into a mass of very refractive granules. These granules gradually become gelatinized, the most resistant of them being located at the proximal end. The capsule of most of the grains becomes dissolved at the distal margin, such grains being reduced largely to a mass of very refractive granules irregularly scattered towards the distal margin, but more compact towards the proximal end, it being bounded at this end and sides nearby by a narrow refractive band of lamellæ. Scattered among these grains are those having an entire ungelatinized margin and the shape of the untreated grain, although the mesial portion is broken into a mass of refractive granules. During gelatinization of the main body of the grain there is a slight lateral protrusion at the distal margin, followed by solution of this end, while the proximal end retains its form and usually remains ungelatinized. The rare completely gelatinized grains are swollen and slightly distorted, having a general resemblance to the untreated grain. Comparison with *C. moorei:* The mesial portion of the grain during disorganization is accompanied by the appearance of granules of greater refractivity. A border at the distal margin is more frequently gelatinized before the mesial region, and a marginal border at the proximal end and sides is the most resistant in both grains; gelatinization is not complete in nearly so many grains, and when complete the gelatinized grains exhibit much less distortion.

The reaction with *sulphuric acid* begins in a few grains in 1 minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 35 per cent of the grains and 62 per cent of the total starch in 15 minutes; in about 50 per cent of the grains and 89 per cent of the total starch in 30 minutes, in about 65 per cent of the grains and 95 per cent of the starch in 45 minutes; and in about 85 per cent of the grains and over 99 per cent of the total starch in 60 minutes (the small percentage of starch ungelatinized is found in small grains). (Chart D 131.)

The reaction with *hydrochloric acid* begins in 2 minutes. None of the grains is wholly gelatinized and only about 1 per cent of the total starch is disorganized in 5 minutes. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 6 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 14 per cent of the total starch in 30 minutes; in about 3 per cent of the grains and 33 per cent of the total starch in 45 minutes; and in about 4.5 per cent of the grains and 35 per cent of the total starch in 60 minutes. (Chart D 132.)

The reaction with *potassium hydroxide* begins in a few grains in 1 minute. Complete gelatinization occurs in only rare grains and in about 1 per cent of the total starch in 5 minutes; in about 3.5 per cent of the entire number of grains and 5 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and in 7 per cent of the total starch in 30 minutes; in about 7 per cent of the grains and 10 per cent of the total starch in 45 minutes; and in about 8 per cent of the grains and 13 per cent of the total starch in 60 minutes. (Chart D 133.)

The reaction with *potassium iodide* begins slowly. Complete gelatinization is noted in only rare grains and only about 1 per cent of the total starch is affected in 5 minutes. Very little progress is noted at the end of 15 minutes, the larger grains being the ones affected. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch

in 30 minutes; in about 1.5 per cent of the grains and 5 per cent of the total starch in 45 minutes; and in about 2 per cent of the grains and 7 per cent of the total starch in 60 minutes. The larger grains are more affected than the smaller. (Chart D 134.)

The fissures become enlarged and more refractive (appearing to inclose gas) much more frequently than in *C. moorei.* The refractivity of the fissures is generally lost, usually without the detection of expelled bubbles. The lamellæ become a little more distinct, but they are not nearly so sharply defined as in *C. moorei.* Fissures of a similar character are formed in grains of this species and of *C. moorei* but the single plume-like fissure is more constant and more frequently diagonal, or having one set of lateral branches longer than the other, than in *C. moorei.* In other grains this median fissure becomes densely branched, and the refractive border at the proximal end and sides becomes penetrated by a dense mass of fissures.

The grains may be resolved into granules, scattered ones along the course of the deep fissures being more brilliant, and occasionally a ruffled distal border may less frequently appear than in *C. moorei.* The more frequent method of gelatinization, however, is manifested in a primary breaking down of the mesial portion by means of densely massed fissures (often without the appearance of granules), and the distal lamellæ become irregular in outline, breaking into irregularly placed granules. The refractive border at the proximal end and sides is broader than in *C. moorei;* often either striated or penetrated by a mass of fissures, but much less frequently differentiated into lamellæ or broken into linear granules than in *C. moorei.* The gelatinized grains are swollen and more frequently very little distorted, even less affected than in *C. moorei.* A very small percentage of the grains is much affected, and only in rare grains is gelatinization complete. Either large refractive fragments, or a fairly broad refractive band, is generally found at the proximal end and sides nearby. This band is broader than in *C. moorei,* and fragmentation is not observed in *C. moorei.*

The reaction with *potassium sulphocyanate* begins in a very few grains in 1 minute, and less than 1 per cent of the total starch is gelatinized at the end of 5 minutes. Complete gelatinization occurs in about 1.25 per cent of the entire number of grains and 3 per cent of the total starch in 15 minutes; in about 2.5 per cent of the grains and 5.5 per cent of the total starch in 30 minutes; in about 5 per cent of the grains and 9 per cent of the total starch in 45 minutes; and in about 6 per cent of the grains and 11 per cent of the total starch in 60 minutes. (Chart D 135.)

The fissures enlarge and become very dark and refractive, but the refractivity is gradually lost, during which minute bubbles are occasionally given off. These fissures are profusely branched, more markedly towards the distal margin. The lamellæ toward the distal margin are often grouped in a refractive band and become more sharply defined and striated, and sometimes internal fissures extend from the distal margin inward through a narrow band of these lamellæ, followed by their rapid gelatinization, forming a narrow, delicate ruffle on an otherwise ungelatinized grain. Gelatinization proceeds along the courses of the deeply branched fissures, with the exception sometimes of the area noted; and the mesial portion is broken into irregularly arranged groups of refractive granules which are more resistant toward both distal and proximal ends, an area between often appearing without granules. The starch is more resistant in a narrow band at the proximal end and sides nearby, the lamellæ of which may become sharply defined and striated, but not usually gelatinized. Only rare grains are completely gelatinized. These are swollen and most distorted at the distal margin, but they bear a general resemblance to the untreated grain. A number of grains are completely gelatinized excepting scattered very refractive granules around the margin, and also a small irregular group at the proximal end. Such grains are usually bounded at the proximal end and sides nearby by a narrow refractive band which in some may be resolved into linear refractive granules. Compared with the reaction in *C. moorei* it will be noted that the refractivity of the enlarged fissures gradually disappears in many grains either without the appearance of a bubble or the gradual giving off of minute bubbles, which is quite a different method of losing refractivity from that observed in *C. moorei.* The lamellæ become less sharply defined and striated, especially through the mesial portion, than in *C. moorei.* The marginal distal border is more refractive, and the lamellæ forming it less quickly sharply defined and striated during gelatinization than in *C. moorei.* The grain is disorganized into many more refractive granules, the reaction, as a rule, does not proceed so far, the marginal border is more frequently gelatinized while the remainder of the grain is little affected, and the gelatinized and semi-gelatinized grains are less distorted and more closely resemble the untreated grain, than in *C. moorei.*

The reaction with *potassium sulphide* begins in rare grains in 1 minute, and even at the end of 5 minutes less than 1 per cent of the total starch is affected, without detectable progress in 15, 30, 45, and 60 minutes. (Chart D 136.)

The fissures at and proceeding from the hilum become much enlarged and more refractive and then less refractive, and, as the refractivity is lost, small to large bubbles are sometimes observed to collect in the fissures. The bubble at the hilum is much more frequently inclosed within a fissure and may enlarge to greater size than in *C. moorei.* A few lamellæ become sharply defined, often either as a small group about midway between the hilum and the distal margin, or one may become very prominent as a boundary between the main body of the grain and a narrow refractive border, the lamellæ of which may gradually become sharply defined and striated. Usually a deep much-branched, plume-like fissure proceeds distalward from the hilum and reaches the margin or the prominent lamella referred to; in the latter case a separate set of fissures may form. The longitudinal fissure is deeper and more branched than in *C. moorei,* while the formation of the separate set is the same as in this species. The grain is disorganized with the appearance of granules as noted in *C. moorei,* but they are more numerous and refractive in the mesial region, and scattered very refractive granules frequently remain along the course of the deep fissures after the remainder

of the grain has been gelatinized. Gelatinization may begin at the distal margin, a narrow distal border being gelatinized without granulation and appearing as a ruffle on the ungelatinized main body of the grain, but the process more frequently advances through the mesial region along the course of the fissures, a refractive border at the proximal end and sides being the most resistant. This process is the same as in *C. moorei* with the exception that no grains were here observed in which it started at the proximal end, which is probably due to the absence of protuberances in this starch. The gelatinized grains are swollen and but little distorted; a refractive striated band frequently remains at the proximal end and sides; and there are scattered refractive granules through the mesial region. The gelatinized grain is less distorted, and both the refractive band and the scattered refractive granules are much more numerous than in *C. moorei*. The gelatinized grains bear some resemblance to the untreated grain, much more than in *C. moorei*.

The reaction with *sodium hydroxide* begins in only rare grains in 1 minute, and less than 1 per cent of the entire number of grains and the total starch is gelatinized at the end of 5 minutes. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 4 per cent of the total starch in 30 minutes; in about 2.25 per cent of the grains and 5 per cent of the total starch in 45 minutes; and in about 3 per cent of the grains and 7 per cent of the total starch in 60 minutes. (Chart D 137.)

The reaction with *sodium sulphide* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 1 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 1.5 per cent of the grains and 2.5 per cent of the total starch in 30 minutes; in about 2.5 per cent of the grains and 3 per cent of the total starch in 45 minutes; and in about the same percentage of the grains and 4 per cent of the total starch in 60 minutes. (Chart D 138.)

A bubble is observed in the enlarged clefts at and proceeding from the hilum, which expands to a large size, and is expelled fairly quickly. This is followed by a loss of refractivity in the fissures. The bubble is much more frequently inclosed within a cleft, enlarges to greater size, and is less transient than in *C. moorei*. A few lamellæ become more sharply defined, but this definition is soon lost, and most of the grains become homogeneous and very refractive. A refractive border is fairly often formed at the distal margin, and it may extend laterally towards the proximal end in which the lamellæ are not distinct, but this border is frequently separated from the main body of the grain by a very refractive, clear lamella. The lamellæ are much less sharply defined over most of the grain, and the refractive border is differentiated from the main body of the grain better than in *C. moorei*. One or two fissures proceed distalward from the hilum. They are deep, much branched, and plume-like, much deeper and more profusely branched than in *C. moorei*. The mesial portion of the grain is disorganized into slightly to very refractive granules, usually quite refractive and irregularly massed. Very refractive scattered granules appear along the course of the deeper main branches of the fissures. The refractive border at the distal margin is fairly often the first part of the grain to become gelatinized, gelatinization then proceeding without the formation of granules, but accompanied by much convoluting of the capsule. A narrow refractive border at the proximal end and sides is profusely striated, but very resistant, often remaining for 60 minutes, at which time the reaction is complete in the rest of the grain. This border is frequently disorganized into very refractive granules which are linearly arranged. The starch is disorganized much more frequently into much more refractive granules than is observed in *C. moorei*. The gelatinized grains are much swollen and considerably distorted when gelatinization is complete, but not so distorted as in *C. moorei*. Grains are often completely gelatinized with the exception of a narrow border at the proximal end and sides, these parts being either very refractive and profusely striated, or broken into linear granules. A group of refractive granules may remain in an area around the hilum.

The reaction with *sodium salicylate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 12 per cent of the grains and 16 per cent of the total starch in 15 minutes; in about 42 per cent of the grains and 48 per cent of the starch in 30 minutes; in about 77 per cent of the grains and 82 per cent of the total starch in 45 minutes; and in about 95 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 139.)

A large bubble appears which is generally inclosed within an enlarged fissure at the hilum; this bubble expands more and is much more frequently inclosed within a cleft than in *C. moorei*. A small bubble occasionally appears at the hilum which is similar in size and action to that of *C. moorei*. A few lamellæ may transiently become more distinct, in only few grains, and the definition is less sharp than in *C. moorei*. The refractive border noted in *C. moorei* is usually present, but it is slower in formation, less frequently surrounds the entire grain, and is less often separated from the rest of the grain by one brilliant lamella than in *C. moorei*. Gelatinization begins at the distal margin and usually extends towards the proximal end, a narrow border at the proximal end and sides nearby usually proving the most resistant; the reaction at the proximal end only following that of the distal margin in a very small proportion of grains, the resistant area of such grains being a band just distal to the hilum; the former method occurs much more and the latter less frequently than in *C. moorei*. Gelatinization is usually accompanied by the formation of small irregularly arranged fissures extending proximalwards from the distal margin and sometimes by irregular lateral clefts, in both cases occasionally extending proximalwards until they reach the hilum; such fissures as above described were not observed in *C. moorei*.

The gelatinized grains are much swollen and distorted so that they do not resemble the untreated grain as in *C. moorei*.

The reaction with *calcium nitrate* begins in very rare grains in 2 minutes. Only very rare grains are in the process of gelatinization and less than 0.5 per cent

of the total starch is gelatinized in 5 minutes. Up to the end of 60 minutes little advancement of disorganization is noted beyond a deepening of the longitudinal fissures, especially in the distal region, and the beginning of gelatinization in a few more grains. Complete gelatinization has occurred in about 0.5 per cent of the entire number of grains and in 1 per cent of the total starch in 60 minutes. (Chart D 140.)

The reaction with *uranium nitrate* begins in rare grains in 1 minute. No grains are completely gelatinized and but about 0.5 per cent of the total starch is disorganized in 5 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 0.5 per cent of the total starch in 15 minutes. Slight progress of gelatinization is noted at the end of 30 minutes, but less than 0.5 per cent of the grains and 1 per cent of the total starch are gelatinized at the end of 45 minutes, with no detectable progress at the end of 60 minutes. (Chart D 141.)

The reaction with *strontium nitrate* begins in rare grains in 2 minutes. Gelatinization is observed in only rare grains and in less than 0.5 per cent of the total starch in 5 minutes. But little progress occurs in 15 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 30 minutes; in about 1.5 per cent of the grains and 2.5 per cent of the total starch in 45 minutes; and in about 2.5 per cent of the grains and 3.5 per cent of the total starch in 60 minutes. (Chart D 142.)

The reaction with *cobalt nitrate* begins in very rare grains in 1 minute. Complete gelatinization of any of the grains was not observed, but the process begins in rare grains, much less than 0.5 per cent of both the entire grains and the total starch in 5 minutes. Very slight progress occurs at periods of 15, 30, 45, and 60 minutes respectively. At the end of 60 minutes complete gelatinization has occurred in but rare grains, and has begun in but few others, the total amount of starch gelatinized being less than 1 per cent. (Chart D 143.) The fissures present in the untreated grain immediately become much enlarged and much more refractive; such fissures not usually present in *C. moorei.* The enlargement and refractivity are gradually lost, followed by a greater extension and branching of the longitudinal fissures. The process of gelatinization begins either at the distal margin, or at one side near the distal margin, and is accompanied by considerable distention of the capsule, as noted in *C. moorei,* but the reaction does not proceed proximalward in nearly so many grains as in *C. moorei,* and the most resistant parts are at the proximal end and sides as noted for this species.

The reaction with *copper nitrate* begins in very rare grains in 1 minute. Complete gelatinization was not observed in any of the grains, and the process has begun in but rare grains, much less than 0.5 per cent in 5 minutes. Complete gelatinization occurs in but rare grains and in about 0.5 per cent of the total starch in 5 minutes. There occurs little if any progress in 30, 45, and 60 minutes respectively. At the end of 60 minutes gelatinization has occurred in less than 0.5 per cent of both the grains and the total starch. (Chart D 144.) In very few of the larger grains the process begins at the distal end of a deep fissure, and is accompanied by distention and some ruffling of the capsule without proceeding farther, the process beginning as noted for many grains of *C. moorei.* In some of the smaller grains the process extends through the mesial portion along the course of well-defined fissures, as noted for some grains of *C. moorei,* the distal margin undergoing gelatinization previous to the proximal end and sides.

The reaction with *cupric chloride* begins in very rare grains in 1 minute. Complete gelatinization was not observed in any grains and the process has begun in but rare grains, much less than 0.5 per cent in 5 minutes. Very slight progress occurs in 15, 30, 45, and 60 minutes respectively. At the end of 60 minutes only about 0.5 per cent of the total starch is gelatinized. (Chart D 145.) Gelatinization is complete in very few grains, in these the process proceeds along the course of sharply defined, longitudinal fissures, deeper and more sharply defined than in *C. moorei,* the distal margin being comparatively much more rapidly gelatinized than the proximal end. In some grains this distal margin was affected much more than the mesial portion and the process was accompanied by extension and some ruffling of the capsule at the distal margin as in *C. moorei.*

The reaction with *barium chloride* begins in only rare grains and by an enlargement and increased refractivity of the clefts, and less than 0.5 per cent of the total starch is gelatinized in 5 minutes. Very little change takes place during 15 minutes, apart from a disappearance of the refractivity, together with an extension of the clefts at and proceeding from the hilum and the deepening of fissures and extension toward the distal end. Even at the end of 60 minutes only about 1 per cent of the total starch is gelatinized. (Chart D 146.)

The reaction with *mercuric chloride* begins in very rare grains in 3 minutes. No complete gelatinization in the entire number of grains was observed and the process was begun in but rare grains, much less than 0.5 per cent, in 5 minutes. Very little progress occurs in 15, 30, 45, and 60 minutes. At the end of 60 minutes about 1 per cent of the total starch is gelatinized. (Chart D 147.) Treatment with this reagent is immediately followed by an enlargement and greater refractivity of the fissures that are present in the untreated grain. Both this enlargement and refractivity are gradually lost, but much more slowly than in *C. moorei.* This is followed by an extension and greater branching of the longitudinal fissures; but only rare grains are gelatinized, a very much smaller percentage than in *C. moorei.*

Crinum hybridum J. C. Harvey (Hybrid).

(Plate 4, fig. 24; Charts D 127 to D 147.)

Histologic Properties.

The majority of the grains are simple in *form* and isolated with the exception of a few which appear in aggregates of from 2 to 5, generally 2 or 3, components. Compound grains are fairly numerous and consist of 2 or 3 components. They are not so numerous as in *C. moorei,* but about the same as in *C. zeylanicum.* Well-defined pressure facets were not observed. The surface of the grain is often irregular owing to the same causes as noted under the parents. They are not quite so irregular as in *C. moorei,* but more so than in *C. zeylanicum.* The occasional large blunt protuberances,

noted in *C. moorei* but not in *C. zeylanicum*, are observed; the lateral curvature at the proximal end is frequently present, as in *C. moorei* but not in *C. zeylanicum;* a secondary set of lamellæ at right angles to or inclosing the primary set is not so frequently present as in *C. moorei*, but more often than in *C. zeylanicum;* the abrupt deflection at or near proximal end of elongated grains present in *C. moorei* was not observed, this also being absent in *C. zeylanicum*. The conspicuous forms of the simple grains are ovoid (which sometimes have the distal end squared), pyriform, elongated ovoid, mussel-shell-shaped, and clam-shell-shaped. The additional forms are triangular with curved sides and rounded angles, oyster-shell-shaped, irregular diamond-shaped, elongated clam-shell-shaped, slipper-shaped, imperfect quadrangular, and nearly round. The components of the conspicuous compound grains are arranged more often like those of *C. moorei* than of *C. zeylanicum*. The compound grain composed of three components of medium size is the same as in *C. moorei*, and the large mussel-shell-shaped grain with a cresentric fissure dividing the grain into one large and one fairly small component is rare, as in *C. moorei*. The majority of the grains are flattened, the number being larger than in *C. moorei*, but not quite so large as in *C. zeylanicum*. In form, the grains are much closer to *C. zeylanicum* than to *C. moorei*.

The *hilum* is a small, round, oval, or lenticular spot, which is a little less refractive than in *C. moorei*, but about the same as in *C. zeylanicum*. Multiple hila of the same number and arrangement are not quite so frequently observed as in *C. moorei*, but more frequently than in *C. zeylanicum*. The hilum is very often fissured, much more frequently than in *C. moorei*, but not quite so often as in *C. zeylanicum*. The cavity and the fissures are of similar character to those of both parents with closer resemblance to *C. zeylanicum*, but the fissures are not so deep as in the latter. The fissure passing from the hilum is very much more frequently observed than in *C. moorei*, but about the same as in *C. zeylanicum*. As a rule, it is neither so long nor so deep as in the latter. The range of eccentricity is from 0.45 to 0.10, usually from 0.15 to 0.10 of the longitudinal axis. The hilum in form, fissuration, number, and refractivity is closely like that of one or the other parent or both parents, but, on the whole, more closely approaches that of *C. zeylanicum* than of *C. moorei*.

The *lamellæ* are demonstrable in a much smaller proportion of grains than in *C. moorei*, but in a larger proportion than in *C. zeylanicum*. When observed they are fairly fine to very fine, and when near the hilum they form rings similar to those noted for both parents, and, as in the parents, the majority tend to follow the outline of the grain. The lamellæ near the hilum are finer, as in both parents, but often they can not be made out for one-third to two-thirds distalward from the hilum, as is usual in *C. zeylanicum*. The presence of one very coarse lamella, and the grouping of fine lamellæ between 2 or sometimes 3 or 4 less fine, refractive lamellæ is found, as in both parents, but with a closer resemblance to the character and arrangement observed in *C. zeylanicum*. Also occasional bands of less fine lamellæ are found, as in both parents, the band at the distal margin being more frequently present than in *C. moorei*, but about the same as in *C. zeylanicum*. The very refractive, wavy lamella limiting this band distally is not observed, as was also the case in *C. moorei*. The presence of a secondary set of lamellæ is less frequent than in *C. moorei*, but more frequent than in *C. zeylanicum*. The number of lamellæ in the primary set of large grains varies from 48 to 64. The lamellæ in character, arrangement, and numbers are in certain respects like one or the other parent or both parents, but on the whole, more closely approach those of *C. zeylanicum* than of *C. moorei*.

The grains vary in *size* from the smaller which are 4 by 3μ, to the larger which are 60 by 48μ, rarely 70 by 26μ, in length and breadth. The common size is about 48 by 32μ. In size and ratio of length to breadth the grains more closely approach *C. zeylanicum* than to *C. moorei*, but in length are closer to the latter.

Polariscopic Properties.

The *figure* is slightly to very eccentric, distinct, and clean-cut. The lines of the majority are slightly broader than in *C. moorei*, but about the same as in *C. zeylanicum;* and they cross each other obliquely, as in the parents. They are less often bent and bisected than in *C. moorei*, and they are straight in almost as many grains as in *C. zeylanicum*. Double figures are not quite so numerous as in *C. moorei*, but about the same as in *C. zeylanicum*.

The *degree of polarization* is very high, very much higher than in *C. moorei*, and a trifle higher than in *C. zeylanicum* (value 95). Variations in the different grains, as in the parents, is observed, but a larger proportion of grains having a very high polarization is present than in either parent. The variation in the same aspect of a given grain is a little less than in *C. moorei*, but about the same as in *C. zeylanicum*.

With *selenite* the quadrants are well defined, unequal in size, and often irregular in shape. They are less irregular than in *C. moorei*, but a little more irregular than in *C. zeylanicum*. The colors are generally pure, but a much larger number of grains of a greenish tinge is found than in *C. moorei* and also a somewhat larger number than in *C. zeylanicum*. In figure, the degree of polarization, and reaction with selenite the grains are more like those of *C. zeylanicum* than of *C. moorei*.

Iodine Reactions.

With 0.25 Lugol's solution the grains color a very light blue-violet (value 35), lighter and less bluish than in *C. moorei*, about the same as in *C. zeylanicum*, and deepen somewhat rapidly to a moderately deep blue-violet that is not quite so deep or so bluish as in *C. moorei*, and of about the same depth and a majority of the grains nearer the color of *C. zeylanicum*, but some are more bluish than in this species. With 0.125 Lugol's solution the grains color a very light violet, lighter and more reddish than in *C. moorei*, but a little deeper and of about the same color as in *C. zeylanicum*. In the majority the color deepens somewhat rapidly to a moderately deep violet, and in others the color is fair. The coloration is lighter but more reddish than in *C. moorei*. The majority have about the same slight reddish tint, but a little deeper color and a few are more bluish than in *C. zeylanicum* (value 17). After heating in water until the grains are gelatinized, and then adding 2 per cent

Lugol's solution, the *grains* are colored a light to a moderately deep blue, a lighter and purer blue than in either parent, and with a closer resemblance to *C. zeylanicum*. The *solution* takes on a deep indigo-blue, a little deeper than in *C. moorei*, but about the same as in *C. zeylanicum*. If the preparation is boiled for 2 minutes, and then treated with an excess of 2 per cent Lugol's solution most of the grain-residues become a moderately light blue, and a few a moderately deep blue, some with reddish tint. They are deeper with less of a reddish tint than in *C. moorei*, but about the same as in *C. zeylanicum*. The *capsules* are of a deep old-rose to a heliotrope, not so reddish as in either parent, but nearer the color of *C. zeylanicum*. In the iodine reactions the resemblances are closer to *C. zeylanicum* than to *C. moorei*.

Aniline Reactions.

With *gentian violet* the grains color moderately at once, deeper than in *C. moorei*, and slightly deeper than *C. zeylanicum*. In half an hour the color is moderately deep to deep (value 70), deeper on the whole than in the parents. The bands of deeper color at or near the distal margin are more frequent than in *C. moorei*, but a little less than in *C. zeylanicum*. The main body of the grain is rarely deeper in color than the band of refractive lamellæ at the distal margin, and is about the same as in *C. zeylanicum*. The occasional secondary lamellæ present usually stain more deeply than the primary set, which is the reverse of what is usual in *C. moorei*, but about the same as in *C. zeylanicum*. The difference in the depth of color of grains with bands as above described is somewhat greater than in *C. moorei*, but a little less than in *C. zeylanicum*.

With *safranin* the grains color lightly at once, a little lighter than in *C. moorei*, but about the same as in *C. zeylanicum*. In half an hour the color is moderate to deep (value 60), on the whole lighter than in the parents, but not so varied in different grains. The unevenness of coloration of the grains which contain bands and secondary lamellæ of deeper color is the same as with gentian violet, but the difference in depth is not so great. The similarities and dissimilarities in relation to the parents are the same as with gentian violet. In the aniline reactions the resemblances are closer to *C. zeylanicum* than to *C. moorei*.

Temperature Reactions.

The majority of grains are gelatinized at 78° to 80° C., and all but rare resistant grains at 80° to 82° C., mean 81° C. The temperature of gelatinization is decidedly closer to *C. zeylanicum* than to *C. moorei*, although higher than either.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in a few in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 6 per cent of the total starch in 15 minutes; in about 10 per cent of the grains, and 12 per cent of the total starch in 30 minutes; and in about 14 per cent of the grains and 18 per cent of the total starch in 45 minutes, with little if any further change in 60 minutes. (Chart D 127.)

A bubble may appear at the hilum or the cleft thereat may become enlarged; the enlarged cleft is much more frequently observed than in *C. moorei*, but not so often as in *C. zeylanicum*. The lack of sharper definition of the lamellæ at once and the formation of the refractive border are observed as in the parents, but the changes much less closely follow *C. moorei* than *C. zeylanicum*. The reaction begins and proceeds as in the parents, but much less frequently advancing from both ends than in *C. moorei*, yet a little more frequently than in *C. zeylanicum*.

The gelatinized grains are swollen and distorted as in the parents, but less at the proximal end than in *C. moorei*, though a little more than in *C. zeylanicum*. At the end of the reaction (60 minutes) many grains have not been affected beyond the initial stages of the process, many more than in *C. moorei*, but less than in *C. zeylanicum*. The non-gelatinized area which remains in partially gelatinized grains is the proximal end, as in parents. The reactions exhibit a much closer relationship to *C. zeylanicum* than to *C. moorei*.

The reaction with *chromic acid* begins in rare grains in 2 minutes. No fully gelatinized grains are observed, but the fissures are much less branched, at the end of 5 minutes. The fissures are deeper and more branched, and some gelatinization has taken place along them, and possibly 2 per cent of the total starch has been gelatinized (but not any entire grains) at the end of 15 minutes. Complete gelatinization occurs in about 25 per cent of the entire number of grains and 75 per cent of the total starch in 30 minutes; in about 96 per cent of the grains and 98 per cent of the total starch in 45 minutes; and of all the starch in 60 minutes. (Chart D 128.)

The reaction with *pyrogallic acid* begins in a few grains in 2 minutes. Complete gelatinization occurs in about 3 per cent of the entire number of grains and in 6 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 12 per cent of the total starch in 15 minutes; in about 20 per cent of the grains (about 40 per cent being entirely unaffected) and 50 per cent of the starch in 30 minutes; in about 25 per cent of the grains and 60 per cent of the total starch in 45 minutes; and in about 40 per cent of the grains and 75 per cent of the total starch (about 20 per cent of the entire number of grains being but little affected) in 60 minutes. (Chart D 129.)

The reaction with *nitric acid* begins in a few grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about the same number of grains and 3 per cent of the total starch in 15 minutes; in a few more grains and 5 per cent of the total starch in 30 minutes; in about 2 per cent of the grains and 6 per cent of the total starch in 45 minutes; and in a slightly larger number of grains and 7 per cent of the total starch in 60 minutes. (Chart D 130.) Gelatinization begins frequently along the distal margin, very much more often than in *C. moorei*, with about the same frequency but accompanied by greater distention though less fluting of the capsule than in *C. zeylanicum*. The minute steps do not resemble *C. moorei* nearly so closely as *C. zeylanicum*, but a crescentic cleft frequently appears a short distance above the distal margin previous to gelatinization of this marginal border, and the distal and lateral margin nearby are heavier in appearance and very much more resistant. The rare grains which are completely gelatinized are swollen and slightly distorted,

much less than in *C. moorei,* but about the same as in *C. zeylanicum.* Many more grains, however, retain their outline at the end of the reaction than in *C. zeylanicum,* the gelatinized distal margin and sides nearby being surrounded by a firm capsule, instead of the capsule being dissolved and leaving a mass of granules at this margin as was noted by *C. zeylanicum.* The reactions exhibit a much closer relationship to *C. zeylanicum* than to *C. moorei.*

The reaction with *sulphuric acid* begins in a few grains in 1 minute. Complete gelatinization occurs in about 1.5 per cent of the entire number of grains and 2.5 per cent of the total starch in 5 minutes; in about 16 per cent of the grains and 35 per cent of the total starch in 15 minutes; in about 30 per cent of the grains and 52 per cent of the total starch in 30 minutes; in about 35 per cent of the grains and 67 per cent of the total starch in 45 minutes; and in about 50 per cent of the grains and 84 per cent of the total starch (about 10 per cent of the grains being apparently unaffected) in 60 minutes. (Chart D 131.)

The reaction with *hydrochloric acid* begins in a few grains in half a minute. Complete gelatinization occurs in less than 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 20 per cent of the total starch in 15 minutes; in a slightly larger percentage of grains and 33 per cent of the total starch in 30 minutes; in about the same number of grains and 35 per cent of total starch in 45 minutes; and in about 5.5 per cent of the grains and 37 per cent of the total starch in 60 minutes. (Chart D 132.)

The reaction with *potassium hydroxide* begins in a few grains in 1 minute. Complete gelatinization occurs in rare grains and 1 per cent of the total starch in 5 minutes; in about 3 per cent of the entire number of grains and 5 per cent of the total starch in 15 minutes; in about 7 per cent of the grains and 11 per cent of the total starch in 30 minutes; in about 11 per cent of the grains and 14 per cent of the total starch in 45 minutes; and in about 13 per cent of the grains and 15 per cent of the total starch in 60 minutes. (Chart D 133.) The reaction is qualitatively nearly the same as in the parents, but with a much closer resemblance to that of *C. zeylanicum.* The small bubble at the hilum is much less frequently observed than in *C. moorei,* but more often than in *C. zeylanicum.* The fissures at and proceeding from the hilum, in which bubbles appear, are much more numerous and prominent than in *C. moorei,* but not quite so many nor usually so refractive as in *C. zeylanicum.* The lamellæ become more distinct over the entire grain, but not nearly so well defined as in *C. moorei,* but closely resemble and are demonstrable in many more grains and more distinct than in *C. zeylanicum.* The gelatinized grains are swollen and distorted, as in both parents, and more frequently have refractive fragments at the proximal end than in *C. moorei,* but about the same as in *C. zeylanicum.* The reactions exhibit a much closer relationship to *C. zeylanicum* than to *C. moorei.*

The reaction with *potassium iodide* begins in a few of the smaller grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and in a little more than 1 per cent of the total starch in 5 minutes; in about 2.5 per cent of the grains and 3 per cent of the total starch in 15 minutes, with scarcely detectable change in 30 minutes; in about 3 per cent of the grains and 3.5 per cent of the total starch in 45 minutes; and in the same percentage of grains and 4 per cent of the total starch in 60 minutes. The smaller grains in this starch, as in *C. zeylanicum,* are less resistant than the large grains, which is the reverse of what is observed in the starch of readily gelatinized species, such as *C. moorei* and *C. zeylanicum.* (Chart D 134.)

The fissures at the hilum become much enlarged and more refractive (apparently inclosing gas) much more often than in *C. moorei,* but somewhat less often than in *C. zeylanicum.* The lamellæ become more distinct, but not nearly so sharply defined as in *C. moorei,* yet considerably more than in *C. zeylanicum.* Fissures of a similar character to those of both parents are formed, but they more closely follow those described in *C. zeylanicum.* The mesial and distal regions may be disorganized into granules as in *C. moorei,* and sometimes in *C. zeylanicum.* The band at the distal margin is more often gelatinized with a ruffled appearance than in either parent. The mesial region of the majority of the grains is disorganized more frequently either with the appearance of scattered, more brilliant granules or without refractive granules when it is penetrated by densely branched fissures than in *C. moorei,* though somewhat less frequently than in *C. zeylanicum.* The border at the proximal end and sides is much less frequently differentiated into lamellæ and broken into granules than in *C. moorei,* but about the same as in *C. zeylanicum.*

The gelatinized grains are swollen, but little distorted, slightly less than the mean of *C. moorei,* but about the same as in *C. zeylanicum.* A small percentage of grains are completely gelatinized, and in only rare grains, in which the reaction is complete, there remains a fairly narrow band at the proximal end and sides which is often broken into fragments, much more frequently than in *C. moorei,* but about as in *C. zeylanicum.* The reactions much more closely follow those of *C. zeylanicum* than *C. moorei.*

The reaction with *potassium sulphocyanate* begins in a few grains in half a minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains (chiefly of the smaller grains) and 1.5 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 15 minutes; in about the same percentage of the grains and 3.5 per cent of the total starch in 30 minutes; in about the same number of grains and 5 per cent of the total starch in 45 minutes; and in about 5 per cent of the grains and 7 per cent of the total starch in 60 minutes. (Chart D 135.)

In the untreated grains at and proceeding from the hilum a cleft and longitudinal fissure are much more frequently present than in *C. moorei;* but less often found than in *C. zeylanicum.* These parts after treatment with the reagent undergo considerable enlargement and increase of refractivity, much greater and much more frequently than in C. *moorei* but the opposite in *C. zeylanicum.* In many grains a well-defined bubble is not observed at the hilum, which is commonly present in *C. moorei;* but the enlargement and refractivity of the cleft at the hilum are gradually lost without the formation of a definite bubble, as was observed in *C. zeylanicum.* The steps of the reaction resemble much less

closely those of *C. moorei* than of *C. zeylanicum*, but in 60 minutes there is a greater variation of the amount of gelatinization of the different grains than in *C. zeylanicum*. At the end of this period a larger proportion of grains is completely gelatinized and the remainder is less affected by the reagent than in *C. zeylanicum*. The gelatinized grains are considerably less distorted and more frequently contain some refractive granules than in *C. moorei*, but they are somewhat more distorted and contain less granules than in *C. zeylanicum*. The reactions much more closely follow those of *C. zeylanicum* than *C. moorei*.

The reaction with *potassium sulphide* begins in very few grains in 1 minute. Complete gelatinization occurs in less than 1 per cent of the entire number of grains (only the smaller grains) and less than 1 per cent of the total starch in 5 minutes; in less than 1 per cent of the grains and 1 per cent of the total starch in 30 minutes, with little if any further progress at the end of 60 minutes. (Chart D 136.)

The enlarged refractive fissure at the hilum is much more frequently seen than in *C. moorei*, but somewhat less so and the gas more quickly collects in bubbles followed by expulsion, and there is a more rapid loss of refractivity than in *C. zeylanicum*. The lamellæ do not become so sharply differentiated as in *C. moorei*, but about the same as in *C. zeylanicum*. Gelatinization begins and proceeds as in the parents. The grains are disorganized with the appearance of more refractive granules than in *C. moorei*, but about the same as in *C. zeylanicum* with the exception that in comparison with the latter the brilliant, scattered granules in the mesial portion are less frequently observed. The gelatinized grains are swollen and but little distorted, and they are less distorted and more frequently retain a band at the proximal end and sides, as well as a few scattered refractive granules, than in *C. moorei*. They are a little more distorted at the distal margin, and the band at the proximal end is usually narrower with fewer refractive granules remaining than in *C. zeylanicum*. The gelatinized grains bear some resemblance to the untreated grain, much more than in *C. moorei* but slightly less than in *C. zeylanicum*. The reactions exhibit a much closer relationship to *C. zeylanicum* than *C. moorei*.

The reaction with *sodium hydroxide* begins in rare grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 6 per cent of the total starch in 30 minutes; in about 5 per cent of the grains and 7 per cent of the total starch in 45 minutes; and in about the same percentage of grains and 8 per cent of total starch in 60 minutes. (Chart D 137.)

The reaction with *sodium sulphide* begins in a few grains in 1 minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 3.5 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 6 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 9 per cent of the total starch in 30 minutes; in about 7 per cent of the grains and 9.5 per cent of the total starch in 45 minutes; and in about 8 per cent of the grains and 15 per cent of the total starch in 60 minutes. (Chart D 138.)

A bubble is less frequently detected at the hilum than in either parent, and when present it is much more often inclosed within an enlarged fissure than in *C. moorei*, but less frequently than in *C. zeylanicum*. A few lamellæ are more sharply defined, but the definition is soon lost and not so distinct over nearly so much of the grain as in *C. moorei*, but about the same as in *C. zeylanicum*. A refractive border is more sharply differentiated from the main body of the grain than in *C. moorei*, but it is slightly less prominent than in *C. zeylanicum*. Fissures appear which are of the same character as those of the parents, but they are deeper and much more profusely branched than in *C. moorei;* yet not so deep and have a character of branching much like that in *C. zeylanicum*. The mesial portion of the grain is disorganized with the appearance of from slightly to very refractive granules, the mean degree of refractivity is much higher than in *C. moorei*, but somewhat less than in *C. zeylanicum*. The distal margin is more frequently the first region to become gelatinized than in either parent; there is more distention of the capsule at this end with a less number of convolutions, and the reaction proceeds farther from this end before much progress occurs around the hilum than in either of the parents. The border at the distal margin is broken down without the appearance of granules, as in the parents. A narrow refractive border at the proximal end and sides is more resistant than in the parents, and it becomes profusely striated and may disorganize into linear granules, the latter not being observed in *C. moorei*, but being the same as in *C. zeylanicum*.

The completely gelatinized grains are much swollen and often much distorted at the distal margin, the mean distortion being considerably less than in *C. moorei* but somewhat more than in *C. zeylanicum*. Grains are often completely gelatinized with the exception of a narrow refractive border at the proximal end and sides nearby, which border may be profusely striated or broken down into linear very refractive granules, together with a group of refractive granules in an area around the hilum, the border usually being broader and the granulation more frequent than in *C. zeylanicum*, the resemblances being more marked to this species than to *C. moorei*. The reactions exhibit a much closer relationship to *C. zeylanicum* than to *C. moorei*.

The reaction with *sodium salicylate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 8 per cent of the total starch in 5 minutes; in about 20 per cent of the entire number of grains and 26 per cent of the total starch in 15 minutes; in about 80 per cent of the grains and 87 per cent of the total starch in 30 minutes; in about 97 per cent of the grains and over 98 per cent of the total starch in 45 minutes; and in all of the starch, excepting small parts of few grains, making over 99 per cent of the total starch gelatinized, in 60 minutes. (Chart D 139.)

A bubble appears at the hilum and is inclosed within an enlarged fissure in the majority of grains; decidedly more frequently than in *C. moorei*, but somewhat less often than in *C. zeylanicum*. The bubble which appears within the hilum expands much more than in *C. moorei*, but less than in *C. zeylanicum*. The definition of the lamellæ and the formation of a refractive border less

closely resembles that noted in *C. moorei* than in *C. zeylanicum.* Gelatinization begins and proceeds as noted in the parents; it follows at the proximal end in a less number of grains than in *C. moorei,* but in somewhat more than in *C. zeylanicum.* The resistant portion is more frequently at the proximal end and sides nearby than in *C. moorei,* but not so frequently as in *C. zeylanicum.* Fissures are much more frequently formed during gelatinization than in *C. moorei,* about the same as in *C. zeylanicum.* The gelatinized grains are much swollen and distorted so that they do not resemble the untreated grain as in both parents. The reactions exhibit a much closer relationship to *C. zeylanicum* than to *C. moorei;* yet characteristics of the latter are more prominent with this reagent than with many others.

The reaction with *calcium nitrate* begins in very few grains in 1.5 minutes. Complete gelatinization occurs in only very rare grains and in less than 0.5 per cent of the total starch in 5 minutes; in about 0.5 per cent of the entire number of grains and 0.5 per cent of the total starch in 45 minutes; and in about 1 per cent of the grains and 2.5 per cent of the total starch in 60 minutes. (Chart D 140.)

The reaction with *uranium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in only rare grains and in about 0.5 per cent of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 1 per cent of the total starch in 30 minutes; in about the same percentage of grains and 2 per cent of the total starch in 45 minutes; and in about the same percentages of both at the end of 60 minutes. (Chart D 141.)

The reaction with *strontium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1.5 per cent of the total starch in 5 minutes; in 1 per cent of the grains and 2.5 per cent of the total starch in 15 minutes; in about 3.5 per cent of the grains and 5 per cent of the total starch in 30 minutes; in about 4 per cent of the grains and 5.5 per cent of the total starch in 45 minutes; and in 5 per cent of the grains and 6.5 per cent of the total starch in 60 minutes. (Chart D 142.)

The reaction with *cobalt nitrate* begins in very rare grains in 1 minute. Complete gelatinization of any of the grains was not observed, and the process had begun in much less than 0.5 per cent of the entire number of grains and about 0.5 per cent of the total starch was gelatinized in 5 minutes. Very slight progress, or less than 1 per cent of the total starch, was gelatinized in 15, 30, 45, and 60 minutes respectively. At the end of 60 minutes complete gelatinization has occurred in but rare grains, and started in but few more. (Chart D 143.)

The fissures are affected in about the same manner, but those of the untreated grain are less prominent, and the branching becomes less prominent after treatment with this reagent, than in *C. zeylanicum,* to the reaction of which, as a whole, there is a closer resemblance than to those of *C. moorei.*

The reaction with *copper nitrate* begins in very rare grains in 1 minute. Gelatinization begins in much less than 0.5 per cent of the grains and less than 0.5 per cent of the total starch is gelatinized in 5 minutes. Very slight progress occurs in 15, 30, 45 minutes, respectively. Only rare scattered grains, usually the smaller, are completely gelatinized, and less than 0.5 per cent of the grains are completely and only about 0.5 per cent of the total starch gelatinized in 60 minutes. (Chart D 144.)

Gelatinization proceeds through the mesial portion along the course of the fissures, the distal margin being much less resistant than the proximal end and sides as noted for both parents. Very few grains were observed undergoing gelatinization, the capsule at the distal margin was not ruffled or extended as was observed in *C. moorei,* and as in as few grains of *C. zeylanicum.* The reactions exhibit a closer relationship to those of *C. zeylanicum* than to *C. moorei.*

The reaction with *cupric chloride* begins in very rare grains in 1 minute. Complete gelatinization was not observed in any grains, the process has begun in much less than 0.5 per cent of the grains and less than 0.5 per cent of the total starch was gelatinized in 5 minutes. Very slight progress occurs in 15 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and in 0.5 per cent of the total starch in 30 minutes; in about 0.5 per cent of the entire number of grains and about 1 per cent of the total starch in 45 minutes; and about 1.25 per cent of each in 60 minutes. (Chart D 145.) The methods of gelatinization more closely resemble those observed in *C. zeylanicum* than in *C. moorei,* but the capsule at the distal margin is less likely to be ruffled than in either parent.

The reaction with *barium chloride* begins in less than 0.5 per cent of the entire number of grains and gelatinization is complete in less than 0.5 per cent of the total starch in 5 minutes. Almost no progress can be detected at the end of 60 minutes. The qualitative reactions are almost exactly the same as in *C. zeylanicum,* the main difference being noticeable in a less depth of fissuration than in this species. (Chart D 146.)

The reaction with *mercuric chloride* begins in very rare grains in 3 minutes. Gelatinization begins in much less than 0.5 per cent of the entire number of grains and is complete in about 0.25 per cent of the total starch in 5 minutes. Very little progress occurs in 15, 30, 45, and 60 minutes. (Chart D 147.) The reaction begins immediately by the enlargement and greater refractivity of the cleft and fissures at and proceeding from the hilum, as in both parents. These fissures are much more often found in the untreated grain than in *C. moorei,* but are not so deep nor so frequently present as in *C. zeylanicum,* and hence the enlargement and change of refractivity are not quite so conspicuous as in the latter species. The reaction much less closely resembles that observed in *C. moorei* than in *C. zeylanicum,* but the fissures do not extend to the distal margin in as many grains of the hybrid as in *C. zeylanicum.* The reactions exhibit a much closer relationship to *C. zeylanicum* than to *C. moorei.*

8. Starches of Crinum zeylanicum, C. longifolium, and C. kircape.

C. zeylanicum is described on pages 454 to 459.

Starch of Crinum longifolium (Pollen Parent).

(Plate 5, figs. 26 and 28; Charts D 148 to D 168.)

Histologic Properties.

In *form* the majority of the grains are simple and isolated with the exception of a few which appear in aggregates of from 2 to 4, usually 2, components. Compound

grains, usually consisting of 2 components, are occasionally observed. Much smaller proportions of both aggregates and compound grains are found than in *C. zeylanicum.* No well-defined pressure facets were observed. The surface of the grain is often irregular, and the irregularities are more prominent and found in a larger number of grains than in *C. zeylanicum.* The irregularities are due chiefly to the same causes as in *C. zeylanicum,* such as the presence of one or more rounded protuberances (often long and larger than in *C. zeylanicum*) located at or near the proximal end; to the shifting of the longitudinal axis of the primary lamellæ; to a secondary set of lamellæ; to depressions on the curved outline which are occasionally concave and resemble a pressure facet; and to a sinuous outline at the distal margin. There is in addition a lateral curvature at the proximal end in a few ovoid grains of medium size. The conspicuous forms are plano-convex, reniform, low and broad triangular with a curved base and rounded angles, broadly lenticular, pyriform, plano-convex with a rounded prominence at the middle of the plane, and ovoid. In addition there are narrow triangular with an elongated proximal end (simulating the shape of a bell), ellipsoidal, clam-shell-shaped, ovoid with a squared distal end, and nearly round. The same forms of compound grains are observed as was noted in *C. zeylanicum,* excepting the mussel-shell-shaped grains, the ovoid grains that are made up of components of unequal size, and the form of grain having linearly arranged components, which are absent. The first two occur fairly often, but the last rarely, in *C. zeylanicum.* The majority of the grains are more broadened and flattened than in *C. zeylanicum,* and when viewed on edge are generally of a very narrow ellipsoidal form (generally more narrow than in *C. zeylanicum*), or rod-shaped with curved ends.

The *hilum* is usually fissured, but not quite so frequently as in *C. zeylanicum.* It may be observed as a round, oval, or lenticular spot which is slightly less refractive than in *C. zeylanicum.* Multiple hila, which are rarely present in *C. zeylanicum,* were not observed in this species, owing perhaps to their being obscured by fissuration. Either a small rounded cavity or a short transverse or diagonal cleft may be located at the hilum, these being similar in character (but the clefts not so numerous) to those in *C. zeylanicum.* The most common types are one short, clean-cut, longitudinal fissure through the hilum, and the Y, T, and stellate fissures. Rarely there are 1 or 2 large, branched fissures passing from the hilum, as in *C. zeylanicum.* The fissures, as a rule, are not so deep as in *C. zeylanicum.* The range of eccentricity is from 0.45 to 0.20, usually about 0.35 to 0.25, of the longitudinal axis, being somewhat greater than in *C. zeylanicum.*

The *lamellæ* are not usually demonstrable throughout the entire grain. The majority are fairly fine to fine. Occasionally they can be observed directly around the hilum in the form of circular or oval rings, but elsewhere they tend to follow the outline of the grain, as noted in *C. zeylanicum.* The lamellæ directly around the hilum are frequently obscured by fissures, but, as a rule, they are much more distinct over an area of one-third to two-thirds distalward from the hilum than in *C. zeylanicum;* and often they are more discernible in this region than in a lustrous band at the distal margin, which is the reverse of that noted in *C. zeylanicum.* One coarse, very refractive lamella at varying distances from the hilum is generally present, and is about as prominent as in *C. zeylanicum.* Sometimes 2 or 3 coarse refractive lamellæ are found, between which the fine lamellæ are grouped, but not so often as in *C. zeylanicum.* A lustrous band in which the lamellæ are generally not discernible, but which when distinct are not so fine as those in body of grain, is much more frequently present than in *C. zeylanicum.* This band is sometimes broader and very often forms a border around the entire grain instead of being restricted to the distal margin as in *C. zeylanicum.* A secondary set of lamellæ placed at varying angles to the primary set is even more rare than in *C. zeylanicum.* The lamellæ forming the border around the grain are of a different character from those of the main body and may represent a secondary set. The number counted on the larger grains varied from 30 to 44, being less than in *C. zeylanicum.*

The *size* of the grains varies from the smaller which are 5 by 4μ, to the larger which are 56 by 64μ, in length and breadth. The common size is about 30 by 42μ. In comparison with the grains of *C. zeylanicum,* the larger grains are larger and those of common size are about the same, but the ratio of length to breadth is reversed, these grains being broader than long while those of *C. zeylanicum* are longer than broad.

POLARISCOPIC PROPERTIES.

The *figure* is usually slightly eccentric to quite eccentric. The figure is more varied, the average degree of eccentricity is less, and it is not so clean-cut as in *C. zeylanicum,* the average being coarser than in *C. zeylanicum.* The lines usually intersect obliquely, and are straight in the majority of the grains; but they are more frequently bent and bisected than in *C. zeylanicum.* The figure is sometimes in the form of a mesial line with bisected ends, which was not observed in *C. zeylanicum.* Double figures are present, but they are not so numerous as in *C. zeylanicum.*

The *degree of polarization* is high to very high (value 83). The polarization varies in different grains from moderately high to extremely high, the range being greater and the proportion extremely high, being considerably less than in *C. zeylanicum.* A variation in the same aspect of a grain often occurs, and it is much greater and more frequently observed than in *C. zeylanicum.*

With *selenite* the quadrants are fairly well defined, usually unequal in size, and often irregular in shape. They are not so well defined and are more irregular than in *C. zeylanicum.* The colors are pure in the majority of the grains, but they are not pure in nearly so many grains as in *C. zeylanicum.* The impurity is usually indicated by a purplish-blue and an orange-yellow, there being also a very small number of grains in which both colors have a greenish tinge, as referred to under *C. zeylanicum.*

IODINE REACTIONS.

With a 0.25 per cent Lugol's solution the grains color immediately a light to moderate blue-violet (value 40), some deeper and more bluish than others. The color deepens rapidly and becomes more bluish. The reaction is somewhat deeper and more bluish and there is greater

variation in depth and tint than in *C. zeylanicum.* With a 0.125 per cent Lugol's solution the grains color a quite light blue-violet which deepens gradually, some being lighter and bluer than others. After heating in water until the grains are gelatinized, and then adding a 2 per cent Lugol's solution, the *grains* color a light to a moderately deep blue, there being a little larger proportion of the former, making the average depth of coloration considerably less than in *C. zeylanicum.* The *solution* colors a moderately deep indigo-blue, a little lighter than in *C. zeylanicum.* If the preparation is boiled for 2 minutes, and then treated with an excess of a 2 per cent Lugol's solution, the *grain-residues* become a light blue, some with a reddish tint, lighter than in *C. zeylanicum.* The *capsules* color a deep old-rose to wine-red, the majority redder than in *C. zeylanicum.*

Aniline Reactions.

With *gentian violet* the grains color moderately light immediately, somewhat lighter than in *C. zeylanicum.* In half an hour they are colored moderate to deep, there being a less number of grains of the latter color than in *C. zeylanicum,* hence the average reaction is lighter than in the latter (value 60). The body of the grain with rare exceptions tends to color more deeply than the lustrous border, this being the reverse of what was observed in *C. zeylanicum.* There is less contrast between these areas of the grain than noted in the latter.

With *safranin* the grains stain lightly at once, somewhat lighter than in *C. zeylanicum.* In half an hour they are colored moderately (value 60). The same tendency is shown for the body of the grain to color more deeply than the lustrous border, but somewhat more markedly than with gentian violet. The differences in the depth of color in the same aspect of a given grain and the variations in the different grains are much less, and the mean coloration of the grains is somewhat lighter, than in *C. zeylanicum.*

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 70° to 71° C., and of all 74° to 75° C., mean 74.5° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 39 per cent of the entire number of grains and 46 per cent of the total starch in 5 minutes; in about 50 per cent of the grains and 57 per cent of the total starch in 15 minutes; in about 62 per cent of the grains and 65 per cent of the total starch in 30 minutes; in about 63 per cent of the grains and 68 per cent of the total starch in 45 minutes, with little if any further change in 60 minutes. (Chart D 148.)

Either a bubble appears at the hilum or the fissure present becomes much enlarged and very refractive. The bubble when present is less resistant and the enlarged cleft is much less frequent in many grains than in *C. zeylanicum.* The lamellæ do not usually become more distinct as in *C. zeylanicum.* A refractive border is formed as in *C. zeylanicum,* but it is frequently broader around the entire margin of the grain and a more brilliant lamella sometimes forms a line of demarcation between the main body of the grain and the border. Gelatinization usually begins at the distal margin or at the convex border (modified distal margin) of the plano-convex grains, similar to that noted for *C. zeylanicum;* but the process often spreads around the entire margin before the region directly around the hilum is affected, while it advances from both ends in other grains. These methods were not observed in *C. zeylanicum.* The gelatinization process is accompanied by considerable distention and much ruffling of the capsule, much greater than in *C. zeylanicum.*

The gelatinized grains are swollen and much distorted, the distortion of the entire margin is greater than in *C. zeylanicum.* At the end of the reaction (60 minutes) a number of grains remain which are but little affected, although a much less number than in *C. zeylanicum.* If the grains are partially gelatinized, the part which remains unaffected is generally the proximal end and the area surrounding the hilum; the enlarged fissure at this latter point remains very refractive as in *C. zeylanicum.*

The reaction with *chromic acid* begins in a few grains in 1 minute. Complete gelatinization occurs in about 35 per cent of the entire number of grains and in about 45 per cent of the total starch in 5 minutes; in about the same percentage of grains and in about 70 per cent of the total starch in 15 minutes; and in all grains but outlines of portions of a few grains and in over 99 per cent of the total starch in 30 minutes. (Chart D 149.)

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 50 per cent of the total starch in 1 minute, in about 65 per cent in 2 minutes, in about 85 per cent in 3 minutes, and in all except traces of the margins of a few scattered grains, making over 98 per cent of the total starch, in 5 minutes. (Chart D 150.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 50 per cent of the entire number of grains and 75 per cent of the total starch in 1 minute; in about 67 per cent of the grains and 89 per cent of the total starch in 3 minutes; in about 75 per cent of the grains and 92 per cent of the total starch in 5 minutes; in about 84 per cent of the grains and 95 per cent of the total starch in 10 minutes; in about the same number of grains and 96 per cent of the total starch in 15 minutes; and in about 92 per cent of the grains and over 99 per cent of the total starch in 30 minutes. At the end of 60 minutes a very small area at the proximal end of very rare grains remains ungelatinized.

The reaction proceeds rapidly through the mesial portion of the grain to the distal margin, the proximal end and sides in most grains proving the most resistant. Exceptions occur when either a prolongation or protuberance exists at the proximal end, which part is then gelatinized before the distal margin. A border located at the convex margin of plano-convex grains may be the first gelatinized; the process then sometimes proceeding across the plane surface before the area directly around the hilum is disorganized. The mesial portion of the grain is disorganized much more rapidly and with less refractive granules than in *C. zeylanicum,* the distal margin is generally more resistant, and the gelatinized grains have the capsule intact instead of dissolving at the distal margin during the gelatinization of the granules as in *C. zeylanicum.* The gelatinized grains are much swollen

and distorted, frequently having a few refractive granules near or at the proximal end.

The reaction with *sulphuric acid* begins immediately, a few grains are gelatinized in 20 seconds, and at least 60 per cent are in the process of dissolution in 1 minute. Complete gelatinization occurs in about 75 per cent of the entire number of grains and 96 per cent of the total starch in 5 minutes, and in over 99 per cent of the total starch in 7 minutes. Gelatinization is complete in all parts in 10 minutes. (Chart D 151.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 70 per cent of the entire number of grains and in 88 per cent of the total starch in 2 minutes, and in 99 per cent of the total starch in 5 minutes. At the end of 5 minutes only parts of rare grains remain unaffected and such parts may resist gelatinization for 10 minutes. (Chart D 152.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 70 per cent of the entire number of grains and in 88 per cent of the total starch in 2 minutes, and in 99 per cent of the total starch in 5 minutes. At the end of 5 minutes only parts of rare grains remain unaffected and such parts may resist gelatinization for 10 minutes. (Chart D 153.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 60 per cent of the entire number of grains and 80 per cent of the total starch in 1 minute; in about 78 per cent of the grains and 90 per cent of the total starch in 5 minutes; in 82 per cent of the grains and 96 per cent of the total starch in 10 minutes; in about 86 per cent of the grains and 97 per cent of the total starch in 15 minutes, and in 93 per cent of the grains and 99 per cent of the total starch in 30 minutes. Only a narrow border at the proximal end and extremely few scattered grains remain ungelatinized. The reaction is qualitatively nearly the same as in *C. zeylanicum.* The fissures at and proceeding from the hilum are not quite so enlarged as in *C. zeylanicum.* The lamellæ in the region near the hilum become much more distinct than in *C. zeylanicum,* and frequently those forming the distal band or marginal border become sharply defined and striated, as noted in *C. zeylanicum.* Gelatinization proceeds along well-defined fissures which are more varied in form than in *C. zeylanicum.* The distal band or marginal border is often gelatinized and forms a ruffled band or border around the main body of the grain which is penetrated by a mass of fissures breaking the starch into refractive fragments. The refractive granules which appear upon disorganization of the lamellæ are much more brilliant in the body of the grain than in the area of the distal band or marginal border, but the granules are not quite so refractive as those observed in rare, completely gelatinized grains of *C. zeylanicum.* The starch at the proximal end and sides nearby is the most resistant in a larger number of grains, as noted in the rare, completely gelatinized grains of *C. zeylanicum.* The proximal end is fairly often gelatinized before a band extending through the region of the hilum, which was not noted in *C. zeylanicum.* The gelatinized grains are swollen and somewhat distorted. It is difficult or impossible to make a satisfactory comparison of these grains with those of *C. zeylanicum* because so few grains are completely gelatinized in *C. zeylanicum,* and, as in the latter, irregular refractive masses frequently cause a wrinkling of the partially gelatinized grains, thus causing them to appear more distorted than those of *C. longifolium.* (Chart D 154.)

The reaction with *potassium iodide* begins immediately and a few grains are gelatinized in 1 minute. Complete gelatinization occurs in about 73 per cent of the entire number of grains and 90 per cent of the total starch in 5 minutes; in about 81 per cent of the grains and 94 per cent of the total starch in 10 minutes; in about 87 per cent of the grains and 97 per cent of the total starch in 15 minutes; in about 90 per cent of the grains and 98 per cent of the total starch in 30 minutes; in about the same percentage of grains and 99 per cent of the total starch in 45 minutes; and in about 94 per cent of the grains and over 99 per cent of the total starch in 60 minutes. The small amount of ungelatinized starch is found in the proximal end of the larger grains and at the extreme margin of small (not minute) grains. Such resistant parts are *Crinum* characteristics. (Chart D 155.)

The fissures at the hilum frequently become much enlarged and evidently inclose gas which usually collects to form a large bubble that may suddenly or gradually collapse. The fissures not so frequently enlarge, but if they do the gas collects much oftener in a bubble and is expelled more quickly (accompanied by loss of refractivity), than in *C. zeylanicum.* The lamellæ become somewhat more sharply defined and striated, slightly more than in *C. zeylanicum.* Fissures are formed which are much branched and have the general characters of those found in *C. zeylanicum,* though the direction of the fissuration often differs owing to the shapes of the grains, and those seen in *C. zeylanicum* penetrating the marginal band are not usually present. The mesial region is generally broken down into fairly to very refractive granules, the latter being found frequently along the course of the deep fissures. These granules are more frequently evenly distributed throughout the mesial region, and they are more often refractive than in *C. zeylanicum.* A band at the distal margin, or around the convex margin of plano-concave grains, may gelatinize without the appearance of granules, and sometimes resembles a slightly gathered ruffle when the main body of the grain is resistant, this ruffle-like form being less gathered but similar to that found in *C. zeylanicum.* The lamellæ at the distal margin are not usually disorganized into linear granules, but gradually gelatinize, and in the plano-convex grains they may form a serrated lining to the caspule. The lack of disorganization into linearly arranged granules is even more frequently observed than in *C. zeylanicum.* The gelatinized grains are swollen; but very little distorted, as in *C. zeylanicum.* About half of the grains are not completely gelatinized and contain either scattered refractive granules or a group of granules around the hilum and a refractive granule or a group of granules around the hilum and a refractive band at the proximal end and sides. This band is striated but rarely differentiated into lamellæ or broken into linear granules, and it is similar to but usually narrower and not so frequently penetrated by fissures, nor broken into fairly large refractive fragments, as in *C. zeylanicum.*

The reaction with *potassium sulphocyanate* begins immediately and a few grains are entirely gelatinized in 1 minute. Complete gelatinization occurs in about 50

per cent of the entire number of grains and 70 per cent of the total starch in 3 minutes; in about 77 per cent of the grains and 93 per cent of the total starch in 5 minutes; in about 80 per cent of the grains and 94 per cent of the total starch in 10 minutes; in about the same percentage of grains and 95 per cent of the total starch in 15 minutes; in about 95 per cent of the grains and 99 per cent of the total starch in 30 minutes; and in all of the starch except minute parts of the extreme margin of rare grains in 60 minutes. The proximal end of the larger grains and scattered smaller grains are the most resistant, and the proximal end and sides of the plane surface of a few plano-convex grains are very resistant. (Chart D 156.)

The fissures enlarge and become very dark and refractive, but this refractivity is quickly lost, accompanied by the expulsion of a large bubble. The latter occurs much more quickly and the bubble is much larger and more commonly present than in *C. zeylanicum*. A refractive band is observed near the distal margin in which the lamellæ are much less sharply defined than in *C. zeylanicum*. Gelatinization is usually much more rapid in the mesial portion at the area around the hilum than at other parts, and the refractive distal band breaks up into more refractive granules and is the more resistant. This is the reverse of that which is commonly noted in *C. zeylanicum*. The granules, however, throughout the grain are usually less refractive than in *C. zeylanicum*. The narrow band consisting of a few lamellæ at the proximal end and sides nearby is the most resistant, as in *C. zeylanicum*. The grains are with rare exceptions completely gelatinized, whereas complete gelatinization is rare in *C. zeylanicum*. The grains are much swollen and but little distorted so that they bear a general resemblance to the untreated grain.

The reaction with *potassium sulphide* begins immediately and a few scattered grains are gelatinized in 1 minute. Complete gelatinization occurs in about 30 per cent of the entire number of grains and 50 per cent of the total starch in 5 minutes; in about 33 per cent of the grains and 55 per cent of the total starch in 15 minutes; in about 40 per cent of the grains and 60 per cent of the total starch in 30 minutes; in about the same percentage of grains and of total starch in 45 minutes; and in about 46 per cent of the grains and 66 per cent of the total starch in 60 minutes. (Chart D 157.)

A bubble forms at the hilum and it may be within an enlarged refractive cleft and often expand to a considerable size. It is inclosed much less frequently but it expands more than in *C. zeylanicum*. The lamellæ sometimes become sharply defined over the entire grain but commonly one lamella, which appears at varying distances from the hilum, is much more distinct than the others. A band distal to this lamella becomes more refractive than the area proximal to it; the lamellæ forming this distal band become gradually more sharply defined and striated, and both the increased definition and striation appear in a larger percentage of grains than in *C. zeylanicum*. Fissures which proceed from the hilum are much branched, as in *C. zeylanicum*, but they are less deep and exhibit more variation in number and direction than in *C. zeylanicum*. Two such fissures extend almost transversely toward the corners of the plano-convex grains, which fissures are quite characteristic of *C. longifolium* but not found in *C. zeylanicum*. Gelatinization begins more frequently in a distal border than in *C. zeylanicum*, probably due to the frequency of this method of gelatinization as in the plano-convex grains which are not found in *C. zeylanicum*. The gelatinization of these plano-convex grains is, however, variable, since in some of them it proceeds distalward from the hilum, while in a larger percentage it begins at the distal convex border. The mesial portion of the grains is often disorganized, accompanied by the appearance of refractive granules, though not in so large a percentage of grains as in *C. zeylanicum*, hence the mean refractivity is less than in *C. zeylanicum*. The most resistant portion usually consists of a narrow, striated, refractive border at the proximal end and sides nearby, as noted in *C. zeylanicum*, but this border is not so broad and it exhibits less resistancy than in *C. zeylanicum*. The gelatinized grains are much swollen and slightly to much distorted, the distortion being more marked at the distal margin. The distortion is greater on the whole than in *C. zeylanicum* and hence the grains bear less resemblance to the untreated grains than in the latter.

The reaction with *sodium hydroxide* begins immediately and many grains are fully gelatinized in 1 minute. Complete gelatinization occurs in about 75 per cent of the entire number of grains and 90 per cent of the total starch in 3 minutes; in about 80 per cent of the grains and 91 per cent of the total starch in 3 minutes; in about 85 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 93 per cent of the grains and 98 per cent of the total starch in 30 minutes; in about the same percentage of each in 45 minutes; and in about 95 per cent of the grains and 99 per cent of the total starch in 60 minutes. The resistant starch is located in the proximal end of a few of the larger grains and in rare smaller grains. (Chart D 158.)

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 46 per cent of the entire number of grains and 52 per cent of the total starch in 5 minutes; in about 50 per cent of the grains and 66 per cent of the total starch in 15 minutes; in about 58 per cent of the grains and 82 per cent of the total starch in 30 minutes; in about 63 per cent of the grains and 84 per cent of the total starch in 45 minutes; and in about 67 per cent of the grains and 91 per cent of the total starch in 60 minutes. (Chart D 159.)

A bubble appears at the hilum and is frequently inclosed within an enlarged fissure. The bubble frequently expands to a large size, and to a greater degree than in *C. zeylanicum*. A few lamellæ become more distinct, as in *C. zeylanicum*. The refractive border at the distal margin (often extending around the entire grain) may become very prominent in more grains than in *C. zeylanicum*. Fissures form which are profusely branched, as in *C. zeylanicum*, but they are generally not so deep. The mesial region is usually disorganized with slightly to fairly refractive granules, a few very refractive granules being scattered along the course of fissures. They are less refractive than in *C. zeylanicum*. The distal margin is often gelatinized first, without the appearance of granules and accompanied with much convoluted distortion more frequently than in *C. zeylanicum*. In other grains this refractive border may be the most resist-

ant, especially when extending around the entire margin, and though profusely striated it is gelatinized without breaking into granules. An entire marginal border was not noted in *C. zeylanicum.* The most resistant portion of the grain is usually a narrow refractive border at the proximal end and sides nearby, as in *C. zeylanicum,* but this border is finally gelatinized without its breaking into granules as seen in *C. zeylanicum.* The gelatinized grains are much swollen and distorted, being more distorted than in *C. zeylanicum.* They bear no resemblance to the untreated grain as in the completely gelatinized grains of *C. zeylanicum.* No partially gelatinized grains are present similar to those of *C. zeylanicum.*

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 29 per cent of the entire number of grains and 37 per cent of the total starch in 5 minutes; in about 56 per cent of the grains and 66 per cent of the total starch in 15 minutes; in about 92 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 98 per cent of the grains and over 99 per cent of the total starch in 45 minutes. Only very rare small grains remain ungelatinized at the end of 60 minutes. (Chart D 160.)

A bubble appears at the hilum. In the majority of the grains it is inclosed within an enlarged fissure at this point, yet not nearly so often as in *C. zeylanicum.* It does not expand so much and is more transient in a larger number of grains than in *C. zeylanicum.* The lamellæ in some grains may become temporarily more distinct. A refractive border appears either at the distal margin or surrounding the entire grain, sometimes being separated from the rest of the grain by a brilliant lamella, and it extends around the entire grain more frequently than in *C. zeylanicum.* Gelatinization begins at the point of union of the plane and convex surfaces (apparently corresponding to the distal corners of other grains) and then may extend along the convex surface in the plano-convex grains. Such a method was not observed in *C. zeylanicum.* In many grains it begins along the distal margin and proceeds gradually toward the proximal end, as in *C. zeylanicum.* When the reaction reaches the bubble, expulsion occurs followed by the very rapid solution of the proximal end and sides. This method is similar to but the gelatinization of the proximal end following the expulsion of the bubble is very much more rapid than that which occurs in *C. zeylanicum.* Gelatinization in some of the plano-convex grains may advance towards the central portion, and in others gelatinization may follow at the proximal end after the distal border has become gelatinized. Gelatinization from two main points is much more common than in *C. zeylanicum.* Definite plume-like fissures are sometimes observed passing from the hilum to the corners of the plano-convex grains, being directed almost transversely from the hilum, but indefinite fissures extending proximalward from the distal margin are not usually present. The definite fissures are much more common and the indefinite fissures much less so than in *C. zeylanicum.* The gelatinized grains are much swollen and distorted, as noted for *C. zeylanicum.*

The reaction with *calcium nitrate* begins in some grains immediately. Complete gelatinization occurs in about 45 per cent of the entire number of grains and 65 per cent of the total starch in 5 minutes; in about 55 per cent of the grains and 78 per cent of the total starch in 15 minutes; in about 65 per cent of the grains and 78 per cent of the total starch in 30 minutes; in about the same number of grains and 81 per cent of the total starch in 45 minutes; and in the same percentage of each at the end of 60 minutes. (Chart D 161.)

The reaction with *uranium nitrate* begins immediately. Complete gelatinization occurs in about 35 per cent of the entire number of grains and 65 per cent of the total starch in 5 minutes; in about 51 per cent of the grains and 74 per cent of the total starch in 15 minutes; in about 61 per cent of the grains and 82 per cent of the total starch in 30 minutes; in about 74 per cent of the grains and 87 per cent of the total starch in 45 minutes; and in about the same percentage of each at the end of 60 minutes. (Chart D 162.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 58 per cent of the entire number of grains and 69 per cent of the total starch in 5 minutes; in about 61 per cent of the grains and 83 per cent of the total starch in 15 minutes; in about 79 per cent of the grains and 97 per cent of the total starch in 30 minutes; in about 87 per cent of the grains and over 98 per cent of the total starch in 45 minutes; and in about the same percentage of each in 60 minutes. (Chart D 163.)

The reaction with *cobalt nitrate* begins immediately. Complete gelatinization occurs in about 23 per cent of the entire number of grains and 34 per cent of the total starch in 5 minutes; in about 31 per cent of the grains and 54 per cent of the total starch in 15 minutes; in about 34 per cent of the grains and 60 per cent of the total starch in 30 minutes; in about 34 per cent of the grains and 65 per cent of the total starch in 45 minutes; and in about 40 per cent of the grains and 70 per cent of the total starch in 60 minutes. (Chart D 164.)

Gelatinization begins, as a rule, at the distal margin as in *C. zeylanicum* and proceeds quite rapidly in some grains, but in others slowly. Gradually, however, after prolonged treatment some of the more resistant grains become completely, or nearly completely gelatinized, a very much larger number than in *C. zeylanicum.* In all grains not completely gelatinized the proximal end and sides nearby prove the most resistant, which is characteristic of the crinums.

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 31 per cent of the entire number of grains and 54 per cent of the total starch in 5 minutes; in about 34 per cent of the grains and 70 per cent of the total starch in 15 minutes; in about 50 per cent of the grains and 78 per cent of the total starch in 30 minutes; in about 57 per cent of the grains and 80 per cent of the total starch in 45 minutes; and in about the same percentage of each in 60 minutes. (Chart D 165.)

In most of the grains gelatinization proceeds through the mesial region along the courses of well-defined fissures, but the distal margin is completely gelatinized before the proximal end and sides nearby. The capsule at the distal margin is more frequently neither ruffled nor especially distended, but in a few grains a band at the margin may be much ruffled and considerably distended

previous to the completion of the reaction in the mesial portion. This reaction proceeds much further than in *C. zeylanicum.*

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in 24 per cent of the entire number of grains and 48 per cent of the total starch in 5 minutes; in about 36 per cent of the grains and 56 per cent of the total starch in 15 minutes; in about 44 per cent of the grains and 60 per cent of the total starch in 30 minutes; in about 46 per cent of the grains and 62 per cent of the total starch in 45 minutes; and in about the same percentage of each in 60 minutes. (Chart D 166.)

Gelatinization proceeds through the mesial region along sharply defined fissures, but the distal margin is gelatinized prior to the proximal end and sides nearby as in *C. zeylanicum.* At the distal margin the process is frequently accompanied by distention and frilling more frequently than in *C. zeylanicum.* The method of gelatinization is similar to but advances in many more grains than in *C. zeylanicum.*

The reaction with *barium chloride* begins in rare grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 8 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 16 per cent of the total starch in 30 minutes; and over 7 per cent of the grains and 19 per cent of the total starch in 45 minutes; and in about 20 per cent of the total starch in 60 minutes. (Chart D 167.)

The reaction with *mercuric chloride* begins in a few grains immediately. Complete gelatinization occurs in about 28 per cent of the entire number of grains and 57 per cent of the total starch in 5 minutes; in about 37 per cent of the grains and 63 per cent of the total starch in 15 minutes; in about 43 per cent of the grains and 70 per cent of the total starch in 30 minutes; in about 54 per cent of the grains and 77 per cent of the total starch in 45 minutes; and in about the same percentage of each in 60 minutes. (Chart D 168.) The fissures present in the untreated grain become much enlarged and more refractive, but both changes disappear quickly in the grains which are gelatinized rapidly, much more quickly than in *C. zeylanicum.* The proximal end and sides nearby of some grains as well as a number of entire grains are resistant, but not nearly so great a percentage are resistant as in *C. zeylanicum.*

CRINUM KIRCAPE (HYBRID).

(Plate 5, fig. 27; Charts D 148 to D 168.)

HISTOLOGIC PROPERTIES.

In *form* the majority of the grains are simple and are isolated with the exception of a few which appear in aggregates of from 2 to 4, usually 2, components. Compound grains, consisting usually of 2 components, are observed. There are smaller proportions of both aggregates and compound grains present than in *C. zeylanicum,* but there are considerably larger proportions than in *C. longifolium.* No well-defined pressure facets were observed. The surface of the grains is fairly often irregular in outline, the irregularities being more obvious and present in a larger number of grains than in *C. zeylanicum,* but somewhat less than in *C. longifolium.* The irregularities are due to the same causes as in the parents. The protuberances at the proximal end are more frequently seen and sometimes larger than in *C. zeylanicum,* but about the same as in *C. longifolium.* A lateral curvature at the proximal end in a few medium-sized ovoid grains may be observed, which was not recorded in *C. zeylanicum,* but noted in *C. longifolium.* The conspicuous forms are ovoid, pyriform, triangular with a curved base and rounded angles, clam-shell-shaped, ovoid with squared distal end, and ellipsoidal. Additional forms are elongated mussel-shell-shaped, low and broad triangular, imperfect plano-convex which have the plane surface more sharply curved than in those of *C. longifolium,* broadly lenticular, narrow triangular with elongated proximal end simulating the shape of a bell, dome-shaped, and nearly round. The same forms of compound grains are observed as noted in the parents, with the exception of grains with linearly arranged components which are rarely found in *C. zeylanicum,* and not observed in *C. longifolium.* The most conspicuous forms are grains with two components of about equal and medium size that are separated by a deep cleft and inclosed by a few common lamellæ, and found in both parents; and mussel-shell-shaped and ovoid grains with one large and one fairly small component separated by a crescentric cleft, which are less numerous than in *C. zeylanicum,* and not observed in *C. longifolium.* Most of the simple grains closely resemble in shape those of *C. zeylanicum,* but scattered among them are several of the laterally extended forms which are similar to but more flattened, the majority less flattened than those of *C. longifolium* and about the same as in *C. zeylanicum.* The majority of grains when viewed on edge are ellipsoidal, and ovoid with pointed end located distally as in *C. zeylanicum,* but a few are of a very narrow ellipsoidal form, as generally found in *C. longifolium.* As a whole, the forms of the grains are closer to those of *C. zeylanicum,* but in certain respects to those of the other parent.

The *hilum* is generally fissured, more frequently than in either parent. The hilum is of the same form as in the parents, but it is slightly more refractive than in *C. zeylanicum,* and considerably more so than in *C. longifolium.* Multiple hila were not observed, but may be obscured by fissuration. The form of the cavity and the clefts located at and proceeding from the hilum are similar to those of the parents. In the majority of the grains the clefts closely resemble but are slightly deeper than those of *C. zeylanicum;* and in the scattered broadened grains additional types of fissures are found which are noted in *C. longifolium.* The range of eccentricity is 0.45 to 0.15, commonly 0.35 to 0.20, of the longitudinal axis. The peculiarities of the hilum generally are closer to those of *C. zeylanicum,* but in eccentricity closer to *C. longifolium.*

The *lamellæ* are rarely demonstrable throughout the entire grain, less often than in the parents, since the region of the hilum in practically all of the larger grains is traversed by deep fissures. When discernible they have the same forms as those described in the parents, the majority being very fine to fairly fine, and coarser when located toward the distal margin. There are usually 1, sometimes 2 or 3, very refractive coarse lamellæ between which the finer ones are grouped. Rarely there is a band

of 2 or 3 fairly coarse lamellæ located about the middle or nearer the distal margin, as is noted in *C. zeylanicum*, but not in *C. longifolium*. With the exception of the region directly around the hilum, the lamellæ are slightly more distinct for one-third to two-thirds distalward from the hilum than in *C. zeylanicum*, but less clear than in *C. longifolium*. The refractive distal band is slightly more brilliant and found on a larger number of grains than in *C. zeylanicum*, but not in quite so large a proportion as in *C. longifolium*. The component lamellæ of the lustrous band are less often discernible than in *C. zeylanicum*, but more often than in *C. longifolium*. This band, even in grains of similar shape to those of *C. zeylanicum*, frequently forms a border around the entire grain. This latter peculiarity is rarely observed in *C. zeylanicum*, but is seen in a majority of the grains in *C. longifolium*. A secondary set of lamellæ placed at varying angles to the primary set is rare, yet it is present more frequently than in either parent. The border of lamellæ around the grain may represent a secondary set of lamellæ. The number of lamellæ in the primary set of the larger grains varies from 48 to 52, but in such grains they were not discernible over the entire surface. The number is about the same as in *C. zeylanicum*, and distinctly greater than in *C. longifolium*.

The *size* of the grains varies from the smaller, which are 8 by 6μ, to the larger elongated grains, which are 70 by 52μ, in length and breadth. The common size of the elongated grains is about 56 by 40μ. There are a number of broadened grains in this species which are rare in *C. zeylanicum*, but commonly present in *C. longifolium*. The larger broadened grains of this hybrid are 58 by 70μ. The common size is 36 by 44μ. In common size the grains are closer to *C. zeylanicum* than to *C. longifolium*, but in some respects the opposite.

Polariscopic Properties.

The *figure* is slightly eccentric to quite eccentric. Its position is much less varied than in *C. zeylanicum*. The average eccentricity is less than in *C. zeylanicum*, but slightly more than in *C. longifolium*. The lines vary from moderately fine to coarse, the average being somewhat coarser than in *C. zeylanicum*, but not so coarse as in *C. longifolium*. The lines usually intersect obliquely, and are straight in the majority of the figures, but they are more often bent and bisected than in *C. zeylanicum*, yet not so frequently as in *C. longifolium*. They are rarely so arranged as to form a mesial line with bisected ends, which figure was not observed in *C. zeylanicum*, but more often found in *C. longifolium* than in the hybrid. Generally, in the characters of the polariscopic figures, the hybrid is more closely related to *C. zeylanicum*.

The *degree of polarization* is very high, slightly higher than in *C. zeylanicum* and distinctly higher than in *C. longifolium*, but much closer to *C. zeylanicum* (value 95). Polarization varies in the different grains from high to extremely high, with the majority very high. The range of variation is the same as in *C. zeylanicum*, but not so great as in *C. longifolium*. Variations in the same aspect of a given grain are slightly greater than in *C. zeylanicum*, but not nearly so marked as in *C. longifolium*.

With *selenite* the quadrants are usually well defined, but not in quite so many grains as in *C. zeylanicum*, yet in many more than in *C. longifolium*. They are unequal in size and slightly irregular in shape, somewhat more irregular than in *C. zeylanicum*, but not nearly so irregular as in *C. longifolium*. The colors are pure in the majority of the grains, an impurity due to a greenish tinge is greater than in *C. zeylanicum* and very much greater than in *C. longifolium*, being closer to *C. zeylanicum*.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains color a light to moderate blue-violet (value 38), which is somewhat deeper and more blue, and deepens a little more rapidly, than in *C. zeylanicum*, but with about the same variation in depth in the different grains. The color is lighter than the average, it deepens less rapidly, and there is less variation in depth in the different grains, than in *C. longifolium*. With 0.125 per cent Lugol's solution the grains color a very light blue-violet which deepens rapidly and is a little more blue, but of about the same depth and variability of color in different grains, as in *C. zeylanicum*; but not so deep as the average, and with less variation, than in *C. longifolium*. After heating in water until the grains are gelatinized and then adding 2 per cent Lugol's solution most of the *grains* color a moderately light blue, and a very few a moderately deep blue. The average is slightly lighter than in *C. zeylanicum*, but a little deeper and with less variation than in *C. longifolium*. If the preparation is boiled for 2 minutes, and then treated with an excess of 2 per cent Lugol's solution, most of the *grain-residues* become a moderately light blue, a few a moderately deep blue, and a few with reddish tint, about the same as in *C. zeylanicum*, but a little deeper than in *C. longifolium*. The *capsules* are colored a deep heliotrope to a wine-red. The average coloration of the capsules is slightly deeper and a little less reddish than in *C. zeylanicum*, and considerably deeper and less reddish than in *C. longifolium*. The reactions are on the whole closer to *C. zeylanicum* than to *C. longifolium*.

Aniline Reactions.

With *gentian violet* the grains color fairly at once, about the same as in *C. zeylanicum*, but the same as in *C. longifolium*. In half an hour the color is moderate (value 60), with a less number of grains of the latter color than in *C. zeylanicum*, hence the average depth of coloration is lighter than in this species (value 60). A band of deep color at the distal margin is sometimes found on the less-colored grains, but the contrast between this band and the body of the grain is not so marked as in *C. zeylanicum*, but more so than in *C. longifolium*. In some grains, notably the low triangular and ellipsoidal with a refractive border around entire grain, the body of the grain tends to color more deeply than the border, which was rarely noted in *C. zeylanicum*, but commonly in *C. longifolium*. The reaction is, on the whole, closer to that of *C. longifolium*.

With *safranin* the grains react lightly at once, but somewhat deeper than in the parents; and in half an hour the color is moderately deep to deep but deeper than in either parent (value 70). The same variations in depth of color in different parts of a given grain are found as was noted under gentian violet. The contrast in depth of color in different parts of the same grain,

and the variations of depth in the different grains, are not so great as in *C. zeylanicum*, but somewhat more marked than in *C. longifolium*. The mean coloration of the grains is closer to *C. zeylanicum*.

Temperature Reactions.

The *temperature of gelatinization* of the majority of grains is 75° to 76°, and of all but rare resistant grains at 77° to 79° C., mean 78° C. The reactions are intermediate between those of the parents, but distinctly nearer those of *C. zeylanicum*.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in very rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and the total starch in 5 minutes; in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 15 minutes; in about 2 per cent of the entire number of grains and 3 per cent of the total starch in 30 minutes; in about 3 per cent of the grains and 4 per cent of the total starch in 45 minutes, with little if any further change in 60 minutes. (Chart D 148.)

Either a bubble appears at the hilum, or the fissure thereat becomes very much enlarged and very refractive. The enlarged fissure is more commonly present than the uninclosed bubble, although the latter is a little more often seen than in *C. zeylanicum* but considerably less than in *C. longifolium*. The lamellæ immediately become more distinct over a larger area of the grain than in the parents. A refractive border is formed similar to that noted in the parents; but a very brilliant lamella may form a line of demarcation between the border and the main body of the grain, this being more frequently observed than in *C. zeylanicum*, but somewhat less often than in *C. longifolium*. The border is broader around the entire margin in a larger number of grains than in *C. zeylanicum* but not in nearly so many as in *C. longifolium*. Gelatinization begins at the distal margin as in both parents, and is accompanied by greater distention but less distortion. The process was not observed to extend around the entire margin, thus much more closely following the method observed in *C. zeylanicum* than in *C. longifolium*.

The gelatinized grains are swollen as in the parents, but are much less distorted. Very few grains are affected by the reagent beyond the initial stages, about the same as in *C. zeylanicum*, but much less than in *C. longifolium*. The fissure remains very much enlarged and very refractive, and if the bubble at the hilum is not inclosed within a cleft it also is large and very persistent. The qualitative reactions show a closer relationship to those observed in *C. zeylanicum* than in *C. longifolium*.

The reaction with *chromic acid* begins in a few grains in 1 minute. Rare grains are gelatinized, there is deep penetration by branched fissures, and less than 1 per cent of the total starch is gelatinized in 5 minutes. Complete gelatinization occurs in less than 1 per cent of the entire number of grains and 5 per cent of the total starch in 15 minutes (the fissures are very deep and branched); in about 35 per cent of the grains and about 80 per cent of the total starch in 30 minutes; in all grains except a part of the margin of rare grains and over 99 per cent of the total starch in 45 minutes; and in all of the starch in 60 minutes. (Chart D 149.)

The reaction with *pyrogallic acid* begins in half a minute. Complete gelatinization occurs in nearly 33 per cent of the total starch, chiefly entire grains, in 5 minutes; in about 70 per cent of the entire number of grains and about 87 per cent of the total starch in 15 minutes, about 10 per cent of the grains being but little affected; in about 75 per cent of the grains and 96 per cent of the total starch in 30 minutes; in about 83 per cent of the grains and 98 per cent of the total starch in 45 minutes; and in about the same percentage of each in 60 minutes. (Chart D 150.)

The reaction with *nitric acid* begins in half a minute. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in about 7 per cent of the grains and 30 per cent of the total starch in 15 minutes; and in about 17 per cent of the grains and over 50 per cent of the total starch in 30 minutes; in about 24 per cent of the grains and 61 per cent of the total starch in 45 minutes; and in about 40 per cent of the grains and 73 per cent of the total starch in 60 minutes. (Chart D 151.)

Gelatinization begins at the distal margin in the form of a rapid swelling, accompanied by considerable distortion and great distention of the capsule, which latter become hyaline and several times the volume of the ungelatinized parts. This process then often proceeds laterally and occasionally even in a narrow band at the proximal end previous to the gelatinization of the area between the hilum and distal gelatinized border. There is usually much greater distention of the capsule at the distal and the lateral than at the proximal margin in grains which are gelatinized as noted above. The capsule at the distal margin frequently becomes distended and slightly to considerably frilled, the distention being greater but exhibiting less frilling than noted in *C. zeylanicum*, though more than in *C. longifolium*. As the reaction proceeds proximally from the distal gelatinized border, a series of crescentic clefts parallel to the distal border are formed, which were not observed in either parent. In other respects the processes of gelatinization more closely follow those of *C. zeylanicum* than of *C. longifolium*.

The gelatinized and semi-gelatinized grains are swollen and somewhat distorted, being about the same as in *C. zeylanicum*, but less distorted and less fully gelatinized than in *C. longifolium*. The qualitative reactions exhibited a closer relationship to *C. zeylanicum* than *C. longifolium*.

The reaction with *sulphuric acid* begins in a few grains in half a minute. Complete gelatinization occurs in about 15 per cent of the entire number of grains and 40 per cent of the total starch in 5 minutes; in about 56 per cent of the grains and 87 per cent of the total starch in 15 minutes; and about 70 per cent of the grains and 96 per cent of the total starch in 30 minutes; and in about 98 per cent of the grains and 99 per cent of the starch in 45 minutes. Only a very narrow border at the proximal end and very little on the sides of few of the grains remain ungelatinized, and even at the end of 60 minutes some traces of ungelatinized starch remain. (Chart D 152.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 2.5

per cent of the entire number of grains and in 37 per cent of the total starch in 5 minutes; in about 11 per cent of the grains and 65 per cent of the total starch in 15 minutes; in about 25 per cent of the grains and 75 per cent of the total starch in 30 minutes; in about 30 per cent of the grains and 84 per cent of the total starch in 45 minutes; and in about 50 per cent of the grains and 85 per cent of the total starch in 60 minutes. (Chart D 153.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 11 per cent of the total starch in 5 minutes; in about 30 per cent of the grains and 52 per cent of the total starch in 15 minutes; in about 40 per cent of the grains and 65 per cent of the total starch in 30 minutes; in about 44 per cent of the grains and 67 per cent of the total starch in 45 minutes; and in about 46 per cent of the grains and 70 per cent of the total starch in 60 minutes. (Chart D 154.)

The reaction progresses somewhat further than in *C. zeylanicum,* but not nearly so far as in *C. longifolium.* The fissures at and proceeding from the hilum become more enlarged and refractive than in either parent. The lamellæ located between the hilum and a few that form the marginal border become more distinct and striated, and more sharply defined than in *C. zeylanicum,* but not so distinct as in *C. longifolium.* The lamellæ forming the marginal border also frequently become more sharply defined and striated, as noted in both parents. Gelatinization proceeds along the course of the fissures, which fissures are more varied in form but more closely resemble those of *C. zeylanicum* than of *C. longifolium.* As the lamellæ are disorganized, refractive granules appear of about the same brilliancy as in *C. zeylanicum,* but more refractive than in *C. longifolium.* The starch at the proximal end and sides nearby is the most resistant in the majority of grains, as noted in both parents, but in a few grains both proximal and distal ends may become completely gelatinized, and a band from each side that extends through the region of the hilum proves the most resistant. The gelatinized grains are swollen and distorted, about the same as those of the parents. The qualitative reactions exhibit a closer relationship to *C. zeylanicum* than *C. longifolium.*

The reaction with *potassium iodide* begins in a few grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 8 per cent of the grains and 18 per cent of the total starch in 15 minutes; in about 13 per cent of the grains and 28 per cent of the total starch in 30 minutes; in about 18 per cent of the grains and 39 per cent of the total starch in 45 minutes; and in about 24 per cent of the grains and 45 per cent of the total starch in 60 minutes. (Chart D 155.)

The fissures at the hilum become much enlarged, more so than in either parent. They are very refractive, inclosing gas, which frequently collects in large bubbles and is expelled as refractivity is lost. The formation of bubbles is much more marked than in either parent. The lamellæ become more sharply defined and striated than in either parent. Fissures are present which are of similar character to those of both parents, but more like those of *C. zeylanicum,* though the one plume-like fissure traversing the main body of the grain is usually deeper and more frequently bifurcated towards the distal margin. The mesial portion undergoes gelatinization that is attended by the appearance of granules, among which are scattered more brilliant granules. These very brilliant granules occur more frequently than in either parent. A distal band may become gelatinized without the appearance of granules, and occasionally this band may extend entirely around the grain. While it appears more frequently it is less distorted and narrower than in *C. zeylanicum,* but more frequently narrower and with about the same distortion as in *C. longifolium.* The lamellæ at the distal margin are more frequently disorganized with the appearance of linearly arranged granules than in either parent; but nearer to that observed in *C. zeylanicum* than in *C. longifolium.* The completely gelatinized grains are much swollen, and are more distorted than in either parent. The grains are usually not completely gelatinized, at least a few brilliant granules being present. In the grains which are almost gelatinized there is frequently found a clear, narrow border around the entire margin. This border is lined by a narrow refractive band that is either striated or broken into linear granules, which was not observed in either parent. The main body of the grain is deeply cut at the fissure, and scattered brilliant granules appear along its distorted margin. These grains do not bear much resemblance to those of either parent. Grains are present, however, in which the refractive band at the proximal end and sides nearby is not outlined by a gelatinized border, and this band is similar to those of the parents, but is usually narrower and more frequently differentiated into lamellæ than in either parent. The qualitative reactions more closely follow those observed in *C. zeylanicum* than in *C. longifolium,* but it exhibits marked individual characteristics.

The reaction with *potassium sulphocyanate* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in about 30 per cent of the grains and 50 per cent of the total starch in 15 minutes; in about 45 per cent of the grains and 70 per cent of the total starch in 30 minutes; in about 48 per cent of the grains and 76 per cent of the total starch in 45 minutes; and in about 62 per cent of the grains and 82 per cent of the total starch in 60 minutes. (Chart D 156.)

The fissures become more enlarged and refractive than in either parent. The refractivity is rapidly lost, accompanied by the expulsion of a very large bubble. The loss of refractivity occurs much more quickly, and the bubble is much larger and observed with much greater frequency than in *C. zeylanicum;* but the refractivity disappears somewhat less rapidly and the bubble is larger than in *C. longifolium.* The relationship in this respect is a little closer to the latter. A refractive border appears at the distal margin where the lamellæ are often indistinct. It is more refractive and the lamellæ are less often demonstrable than in *C. zeylanicum,* but the border is not quite so refractive and lamellæ are more frequently demonstrable than in *C. longifolium.*

The beginning of gelatinization is more varied than in either parent. It may start at the distal margin, accompanied by greater distention of the capsule than in

C. zeylanicum; but this method was not observed in *C. longifolium*. In other grains gelatinization is more rapid in the mesial portion near the hilum, the lamellæ forming the refractive band at the distal margin being the more resistant and breaking into more refractive granules which are sometimes linearly arranged. This method was not observed in *C. zeylanicum,* but usually in *C. longifolium.* The narrow refractive band at the hilum and sides nearby is the most resistant part, as in both parents. The gelatinized grains are much swollen, but completely gelatinized grains are scarce. Many grains, however, are wholly gelatinized with the exception of a few scattered, very brilliant granules which are located around the margin. A small group of granules at the proximal end is somewhat less often seen than in *C. zeylanicum,* but much more often than in *C. longifolium.* The wall of the gelatinized grain is usually thick throughout, with little distortion, thicker and less distorted at the distal end than in *C. zeylanicum,* but thicker and with about the same distortion as in *C. longifolium.* The gelatinized grains bear a general resemblance to the untreated grain. The qualitative reactions in the majority of grains more closely follow those of *C. zeylanicum,* but several show marked resemblance to those of *C. longifolium.*

The reaction with *potassium sulphide* begins in a few grains in half a minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about the same percentage of grains and 2 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 3 per cent of the total starch in 30 minutes; in about the same percentage of each in 45 minutes and 60 minutes respectively. (Chart D 157.)

The fissures at and proceeding from the hilum are much enlarged and very refractive. A large bubble quickly forms and is soon expelled as the fissures lose their refractivity. A bubble is much more commonly observed and the refractivity is more quickly lost than in *C. zeylanicum;* the bubble is more frequently inclosed within a fissure, and enlarges more, but is expelled somewhat less quickly, than in *C. longifolium.* The lamellæ become distinct and striated over more of the grain than in *C. zeylanicum,* but they are not so frequently distinct near the hilum as in *C. longifolium.* The fissures are much branched and very deep, the arrangement and depth more closely resembling that of *C. zeylanicum* than of *C. longifolium.* A refractive border penetrated by a separate set of fissures is more common than in either parent, but closer to *C. zeylanicum* than to *C. longifolium.* Gelatinization frequently begins in a clear lamella which serves as a boundary between the main body of the grain and the refractive border, followed by gelatinization of this border with distention of the capsule. This gelatinized portion may remain bounded distally, and sometimes laterally, by a narrow refractive band which is frequently gradually disorganized into linearly arranged granules previous to gelatinization. This gelatinized border may eventually be quite broad, but seldom is it much ruffled. This method was not observed in either parent. Gelatinization begins more frequently in this border which is bounded for a longer period at the extreme distal margin by an ungelatinized portion, and is eventually deeper but less distorted, than in the parents. Gelatinization in the majority of the grains, however, proceeds along the courses of fissures from the hilum through the mesial portion, this region being broken down into refractive granules; a larger number of the scattered, very brilliant granules appearing than in either parent, but closer to *C. zeylanicum* than to *C. longifolium.* The most resistant portion of the grain is the border at the proximal end and sides nearby, which is gelatinized frequently without breaking into linearly arranged granules, as in the parents.

The gelatinized grains are much swollen and somewhat distorted, more swollen and distorted than in *C. zeylanicum,* but less distorted than in *C. longifolium.* The grains are frequently not completely gelatinized, a refractive border and scattered very refractive granules which very often are grouped around the hilum may remain. The border is less frequently and the granules more frequently observed than in *C. zeylanicum,* but both are more frequently present than in *C. longifolium.* The qualitative reactions exhibit a closer relationship to *C. zeylanicum* than to *C. longifolium,* but a closer relationship to the latter is evident in some grains; and also marked individualities of its own are observed.

The reaction with *sodium hydroxide* begins in a few grains in half a minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 2.5 per cent of the grains and 20 per cent of the total starch in 15 minutes; in about 7 per cent of the grains and 29 per cent of the total starch in 30 minutes; in about 15 per cent of the grains and 33 per cent of the total starch in 45 minutes; and in about the same percentage of each in 60 minutes. (Chart D 158.)

The reaction with *sodium sulphide* begins in a few grains in half a minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 12 per cent of the total starch in 15 minutes; in about 11 per cent of the grains and 27 per cent of the total starch in 30 minutes; in about 14 per cent of the grains and 35 per cent of the total starch in 45 minutes; and in about 22 per cent of the grains and 42 per cent of the total starch in 60 minutes. (Chart D 159.)

A bubble appears at the hilum and is usually inclosed within an enlarged fissure, and it expands to a great size, even more than in either parent. The lamellæ become sharply defined over more of the grains than in either parent. The refractive border, in which the lamellæ are not clearly defined, is more prominent than in the parents, and frequently extends around the entire margin, which was not observed in *C. zeylanicum,* but seen in *C. longifolium.* Fissures are seen having the same general characters, but deeper and even more profusely branched, than in the parents; but their directions are closer to those of *C. zeylanicum.* The mesial region is disorganized with the appearance of refractive granules; they are not so numerous, but scattered ones are more refractive, than in *C. zeylanicum;* they are much more numerous and refractive than in *C. longifolium.* The reaction more frequently begins either at the distal margin or in a clear brilliant lamella a short distance from this margin, followed by gelatinization of the distal margin with greater distention of the capsule but with

somewhat less distortion than in the parents. When this border does not extend around the entire grain, a narrow border at the proximal end and sides nearby is the most resistant part, and it becomes much striated but is usually gelatinized without breaking into granules, much less frequently than in *C. zeylanicum,* about as in *C. longifolium.* The gelatinized grains are much swollen and distorted, more than in *C. zeylanicum,* and quite as much as in *C. longifolium.* A small percentage of the grains otherwise gelatinized have a narrow refractive border remaining at the proximal end and sides nearby, sometimes also a group of granules in the area around the hilum, less frequently than in *C. zeylanicum,* but much more frequently than in *C. longifolium.* The qualitative reactions exhibit a little closer relationship to *C. zeylanicum,* but in many grains characteristics of *C. longifolium* occur, and methods of gelatinization which are characteristic of the hybrid are evident.

The reaction with *sodium salicylate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 6 per cent of the grain and 9 per cent of the total starch in 15 minutes; in about 35 per cent of the grains and 40 per cent of the total starch in 30 minutes; in about 60 per cent of the grains and 69 per cent of the total starch in 45 minutes; and in about 73 per cent of the grains and 78 per cent of the total starch in 60 minutes. (Chart D 160.)

A bubble appears at the hilum usually inclosed within a much enlarged fissure. The bubble expands more and resists expulsion longer than in either parent, but closer to *C. zeylanicum* than to *C. longifolium.* The lamellæ may become temporarily more distinct, and a refractive border appears which may be separated from the rest of the grain by one very brilliant lamella; this refractive border more frequently extends around the entire grain than in the parents, but less often observed in *C. zeylanicum* than in *C. longifolium.* Gelatinization begins and proceeds more frequently as observed in *C. zeylanicum* than in *C. longifolium;* although the border at the proximal end and sides nearby is not quite as resistant and the reaction may proceed from both the distal and the proximal ends more frequently than in *C. zeylanicum,* while the proximal end and sides nearby are decidedly more resistant than in *C. longifolium.* Irregular fissures of the same character appear but are less frequent than in *C. zeylanicum,* and are much more common than in *C. longifolium.* Definite fissures starting from the hilum were not observed, which is the same as was noted for *C. zeylanicum,* but such fissures had been recorded in *C. longifolium.* The gelatinized grain is about the same as in the parents. At the end of the reaction more grains remain but little affected than in either parent. The bubble is very large and very resistant, and may mechanically interfere with the action of the reagent. The qualitative reactions exhibit a decidedly closer relationship to *C. zeylanicum* than to *C. longifolium.*

The reaction with *calcium nitrate* begins in a few grains in 1.5 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 11 per cent of the total starch in 15 minutes; in about the same percentage of grains and 15 per cent of each in 30 minutes; in about 9.5 per cent of the grains and 19 per cent of the total starch in 45 minutes; and in about 20 per cent of the total starch in 60 minutes. (Chart D 161.)

The reaction with *uranium nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in only rare grains and in about 0.5 per cent of the total starch in 5 minutes; in about 2.5 per cent of the grains and 3.5 per cent of the total starch in 15 minutes; in about 3.5 per cent of the grains and 6 per cent of the total starch in 30 minutes; in about the same percentage of grains and in 8 per cent of the total starch in 45 minutes; and in about the same percentage of grains and 10 per cent of the total starch in 60 minutes. (Chart D 162.)

The reaction with *strontium nitrate* begins in rare grains in half a minute. Complete gelatinization occurs in only rare grains and in less than 0.5 per cent of the total starch in 5 minutes; in only rare grains and in about 3 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 6 per cent of the total starch in 30 minutes; in about 8 per cent of the grains and 15 per cent of the total starch in 45 minutes; and in about 25 per cent of the grains and 32 per cent of the total starch in 60 minutes. (Chart D 163.)

The reaction with *cobalt nitrate* begins in very rare grains in 1 minute. Gelatinization occurs in much less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and total starch in 15 minutes; in about 1 per cent of the grains and total starch in 30 minutes; in very slightly more of each in 45 minutes; and in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 60 minutes. (Chart D 164.) Gelatinization begins at the distal margin of the few grains in which the process is noted; similar to that observed for both parents.

The reaction with *copper nitrate* begins in rare grains in 1 minute. Much less than 0.5 per cent of the entire number of grains and the total starch are gelatinized in 5 minutes. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 4 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and in 5 per cent of the total starch in 30 minutes; in about 4 per cent of the grains and 7 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 8 per cent of the total starch in 60 minutes. (Chart D 165.)

Gelatinization is more rapid at the distal margin. It may begin there and be accompanied by considerable extension but very little if any ruffling, much less of the latter than in both parents; the extension more closely resembles *C. zeylanicum* than *C. longifolium.* In other grains the process extends along the course of the deep fissures from the hilum to the distal margin, the mesial portion and the distal margin being much less resistant than the proximal end and sides nearby, as noted in both parents. The reactions exhibit a closer relationship to *C. zeylanicum* than *C. longifolium.*

The reaction with *cupric chloride* begins in very rare grains in 1 minute. Complete gelatinization was not observed in any grains and the process has begun in very rare grains, much less than 0.5 per cent in the entire number of grains, and 0.5 per cent of the total starch

is gelatinized in 5 minutes. Slight progress occurs in 15 minutes. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 30 minutes; in about 2 per cent of the grains and 6 per cent of the total starch in 45 minutes; and in about 4 per cent of the grains and 8 per cent of the total starch in 60 minutes. (Chart D 166.) Gelatinization proceeds through the mesial portion along the course of very deep fissures, and the distal margin is gelatinized more quickly than the proximal end and sides nearby as in both parents. In some grains the process at the distal margin is accompanied by considerable extension and very little fluting of the capsule. In such grains the extension is greater but the fluting less than in the parents; a little closer to *C. zeylanicum* than *C. longifolium*.

The reaction with *barium chloride* begins in very rare grains in 5 minutes. Complete gelatinization was not observed in any grains, and the process began in very rare grains, much less than 0.5 per cent of the entire number of grains, and about 0.5 per cent of the total starch is gelatinized in 5 minutes. Very little if any progress is noted in 15, 30, 45, and 60 minutes respectively. At the latter time much less than 0.5 per cent of the entire number of grains and total starch is gelatinized. (Chart D 167.) The enlargement and refractivity disappear more slowly than in either parent, and is followed by an extension and greater branching of the longitudinal fissures without gelatinization, except in rare grains, as noted in *C. zeylanicum*, but not in *C. longifolium*.

The reaction with *mercuric chloride* begins in rare grains in 3 minutes. Complete gelatinization was not observed in any grains, and was begun in but very few in 5 minutes. About 1 per cent of the total starch is gelatinized in 15 minutes, little if any progress occurs in 30 minutes. About 2 per cent of the total starch is gelatinized in 45 minutes; and about 1 per cent of the entire number of grains and 4 per cent of the total starch are gelatinized in 60 minutes. (Chart D 168.) The fissures, which are very large in the untreated grain, react in the same manner as noted in the parents, but in many grains retaining the increased size and refractivity even longer than in *C. zeylanicum*. The reaction is close to *C. zeylanicum*.

9. Starches of Crinum longifolium, C. moorei, and C. powellii.

Starches of *C. longifolium* and *C. moorei* are described on pages 464 to 470, and 450 to 454, respectively.

Crinum powellii (Hybrid).

(Plate 5, fig. 30; Charts D 169 to D 189.)

Histologic Properties.

In *form* the majority of the grains are simple and isolated with the exception of a few which appear in aggregates of from 2 to 10, usually 2, components. Compound grains, consisting usually of 2 components, are occasionally observed. A larger number of both aggregates and compound grains are found than in *C. longifolium*, but not quite so many as in *C. moorei*. No well-defined pressure facets are present. The surface of the grain is often irregular, and the irregularities are more prominent and numerous than in *C. longifolium*, but not quite so many grains are irregular as in *C. moorei*. The irregularities are due to the same causes as found in the parents, such as the presence at or near the proximal end of one or more protuberances, which when at the latter location are occasionally quite large and sometimes blunt; to the shifting of the longitudinal axis of the primary lamellæ to a secondary set of lamellæ; to slight depressions on the curved margin, occasionally becoming deeper, or shallow concave, at the distal end; to a sinuous outline at the distal margin; to a lateral curvature at the proximal end; and, rarely, to an abrupt deflection of elongated slender grains at or just distal to the slightly eccentric hilum. The last peculiarity was not observed in *C. longifolium*, but was present in *C. moorei*. The conspicuous forms are pyriform, elongated ovoid, sometimes squared at distal end; broad and narrow triangular, clam-shell-shaped; low, broadened triangular; and plano-convex. The additional forms are oyster-shell-shaped; elongated pyriform; club-shaped; somewhat quadrangular; pure ovoid; boot-shaped; and nearly round. Compound grains are not very numerous, but conspicuous forms generally consist of 2 components of medium size inclosed in a few common lamellæ, making the grain ellipsoidal or imperfect heart-shaped, as in the parents. Compound grains consisting of 2 small components inclosed in many lamellæ are found about as rarely as in *C. longifolium*, but much more rarely than in *C. moorei*. The majority of the grains are not so broadened and flattened as in *C. longifolium*, yet slightly more flattened than in *C. moorei*. The grains when viewed on edge are usually ellipsoidal or ovoid with the pointed end located distally. The grains, on the whole, are closer to those of *C. moorei* than to those of *C. longifolium*.

The *hilum* is a small, round, oval or lenticular, refractive spot. It is more refractive than in *C. longifolium*, but about the same as in *C. moorei*. Multiple hila are rarely present, being less often seen than in *C. moorei*, but not observed at all in *C. longifolium*. Either a small rounded cavity or fissures may frequently be found at the hilum. The small cavity is more often observed, but the fissures are, as a rule, more delicate and appear in somewhat fewer grains than in *C. longifolium*; but the cavity is about the same, while the fissures are more often found and are deeper than in *C. moorei*. The clefts are more varied than in the parents. They frequently appear as one short transverse, diagonal, or crescentic fissure; and sometimes a group may be arranged so as to form soaring-bird, cruciate, stellate, thorn-shaped, or T- or Y-shaped figures. One or sometimes two short fissures which are often ragged may pass from the hilum. The range of eccentricity is usually about 0.35 to 0.20 of the longitudinal axis, about the same as in *C. longifolium*. The resemblances in characters generally are, on the whole, much closer to *C. moorei* than to *C. longifolium*.

The majority of the *lamellæ* are from moderately fine to very fine, and when demonstrable they are usually seen as circular or oval rings continuous to the hilum, but a short distance out they tend to have the shape of the outline of the grain. The lamellæ are generally demonstrable throughout the entire grain, being more distinct than in *C. longifolium*, but less so than in *C. moorei*. They are usually finer and less discernible near the hilum, sometimes being scarcely demonstrable

within an area about one-fourth of the distance from this point to the margin. One comparatively coarse and refractive lamella, which is placed at varying distances from the hilum, is usually present, and often the fine lamellæ may be arranged in groups between two or more fairly coarse refractive lamellæ, the number varying according to shape and length of grain. Occasionally a band of 2 or 3 moderately coarse lamellæ are found about the middle or somewhat nearer the distal end of the grain. A lustrous band in which the lamellæ may be very indistinct is sometimes present at the distal margin, or in the form of a marginal border around the grain. This band is less frequently observed, but the component lamellæ are often more discernible than in *C. longifolium;* but it was not observed extending around the entire margin in the grains of *C. moorei.* A secondary set of lamellæ placed at varying angles to the primary set is rarely observed, although slightly more often than in *C. longifolium,* but less so than in *C. moorei.* Since the lamellæ forming the band are of a different character from those of the main body of the grain, and are separated from the latter by a lamella that is coarse and refractive, as in both parents, they may represent a secondary set. The number counted in the primary set of large grains varies from 45 on the broadened grains to 65 on the elongated grains. The lamellæ in character and number more closely approximate those of *C. moorei* than those of the other parent.

The *size* of the grains varies from the smaller which are 3 by 2μ, to the larger elongated forms which are 72 by 34μ, and the broadened grains which are 62 by 80μ, in length and breadth. The common size of the elongated forms is 42 by 28μ, and of the broadened forms 36 by 44μ, in length and breadth. The grains are much more evenly divided into elongated and broadened grains than in either parent. On the whole, the grains more closely approximate those of *C. moorei.*

Polariscopic Properties.

The *figure* is slightly eccentric to very eccentric. The mean is more eccentric than in *C. longifolium,* and while the range is the same as in *C. moorei* in the majority, the figure is not so eccentric and hence the mean is slightly less than in the latter. The figure is usually clean-cut, more so than in *C. longifolium,* but owing to more variation in the different grains it is not so clean-cut as in *C. moorei.* The *lines* are usually fine and intersect obliquely. They are sometimes straight, but frequently bent and bisected; more often bent than in *C. longifolium,* though less often than *C. moorei.* Double figures are more numerous than in *C. longifolium,* but less numerous than in *C. moorei.*

The *degree of polarization* is high to very high (value 85). The polarization of the individual grains has the same range as in both parents, but a larger proportion of the high to very high are found than in *C. longifolium,* making the mean polarization slightly higher than in *C. longifolium,* but about the same as in *C. moorei.* A variation in the polarization is moderately often found in the same aspect of a given grain, not so frequently as in *C. longifolium,* but about the same as in *C. moorei.*

With *selenite* the quadrants are usually well defined, unequal in size, and often irregular in shape. They are more sharply defined and less regular in shape than in *C. longifolium,* but slightly less sharply defined and with about the same irregularity as in *C. moorei.* The colors are usually pure, the yellow is less often pure than the blue, and the impurity of color is indicated in a few grains by a greenish tint to both colors. The colors are more often pure than in *C. longifolium,* and almost the same, but with a little more impurity due to a greenish tinge, than in *C. moorei.* The polariscopic properties without and with selenite are more closely related to those of *C. moorei* than to *C. longifolium.*

Iodine Reactions.

With 0.25 Lugol's solution the grains immediately color a light to moderate blue-violet (value 47), which is a little deeper and more blue than in *C. longifolium,* and the mean of the majority of grains slightly lighter than in *C. moorei.* The color deepens rapidly, with greater variation among the grains than in either parent, the mean being a little deeper than *C. longifolium,* but lighter than in *C. moorei.* With 0.125 Lugol's solution the grains color a very light violet, which deepens somewhat rapidly, becoming more bluish, the grains varying in depth of color from light to moderately deep, a little deeper than in *C. longifolium,* but somewhat lighter than *C. moorei;* and with greater variation in depth than in either parent. After heating in water until the grains are gelatinized and then adding a 2 per cent Lugol's solution, the *grains* color a moderate indigo-blue, some with reddish tint, and the *solution* a moderately deep indigo-blue. The blue grains are more uniform in tint, and the mean coloration is a little deeper than in *C. longifolium.* Some have a reddish tint which was not noted in *C. longifolium.* The blue grains are a little lighter in color and more of the grains have a reddish tint than in *C. moorei.* If the preparation is boiled for 2 minutes, and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* color a very light blue with reddish tint, the *capsules* a light old-rose to wine-red, and the *solution* a deep indigo-blue. The *grain-residues* are lighter blue and more reddish, and the mean of the color of the capsule is lighter and more reddish than in *C. longifolium,* while both are slightly lighter than in *C. moorei.* In these reactions the closer relationship to *C. moorei* is manifest.

Aniline Reactions.

With *gentian violet* the grains color lightly at once and in half an hour they are colored moderate to moderately deep, there being more of the latter coloration than in either parent, the mean being deeper than in *C. longifolium* and the same as that in *C. moorei* (value 65). The body of the grain tends to color more deeply than the lustrous band which is located at the distal margin or which forms a marginal border around entire grain. A narrow band of deeper color is occasionally found about the middle or nearer the distal margin which probably represents the band of coarser lamellæ sometimes located at this point. The same peculiarities were also noted in both parents.

With *safranin* the grains stain lightly at once, and in half an hour they are colored moderately deep to deep. The coloration is deeper and with a slightly different tint of red than in *C. longifolium,* but of the same depth and tint as in *C. moorei* (value 65). The same tendency for the body of the grain to color more deeply than the

lustrous border is observed, and for the occasional band located at the middle or nearer the distal end of the grain to color more deeply than the body of the grain, but somewhat more markedly than with gentian violet.

In the aniline reactions a closer relationship is exhibited to *C. moorei* than to *C. longifolium*.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 65° to 67° C., and of all 68° to 69° C., mean 68.5° C. The temperature reactions are much closer to *C. moorei* than to *C. longifolium*.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 36 per cent of the grains and 46 per cent of the total starch in 5 minutes; in about 55 per cent of the grains and 59 per cent of the total starch in 15 minutes; in about 65 per cent of the grains and 70 per cent of the total starch in 30 minutes; in about 72 per cent of the grains and 80 per cent of the starch in 45 minutes; in about 75 per cent of the grains and 90 per cent of the total starch in 60 minutes. (Chart D 169.)

Either a bubble appears at the hilum or the fissure present thereat becomes enlarged and refractive. A bubble that is not inclosed within a fissure is much less frequently present than in *C. longifolium* and somewhat less often than in *C. moorei*. The lamellæ do not become more distinct in most grains at once as in the parents, but gradually the definition grows sharper than in the parents. A refractive border is formed which somewhat less frequently broadens at the proximal end than in *C. longifolium*, but more often than in *C. moorei*. Gelatinization generally begins at the distal margin but frequently spreads rapidly around the entire grain, but not quite so often as in *C. longifolium*, yet more frequently than in *C. moorei*. Gelatinization may also advance from both ends as noted in the parents. The process is accompanied by distention and distortion of the capsule as in both parents.

The gelatinized grains are swollen and distorted as in both parents. At the end of the reaction (60 minutes) a few grains remain that are but little affected by the reagent—decidedly less than in *C. longifolium*, but a few more than in *C. moorei*. In the partially gelatinized grains the proximal end with the area surrounding the hilum is the most resistant, a bubble at the hilum in such grains usually persisting. The reactions with chloral hydrate exhibit a closer relationship to those observed in *C. moorei* than in *C. longifolium*.

The reaction with *chromic acid* begins in a few grains in half a minute. Complete gelatinization occurs of about 35 per cent of the entire number of grains and 55 per cent of the total starch in 5 minutes; of about 88 per cent of the grains and 97 per cent of the total starch in 15 minutes; in over 99 per cent of the total starch in 20 minutes; and in all of the starch in 25 minutes. (Chart D 170.)

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization of many grains occurs in half a minute; of about 80 per cent of the total starch in 1 minute; of over 99 per cent of the total starch in 2 minutes; and of all of the starch in 3 minutes. (Chart D 171.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs of about 50 per cent of the entire number of grains and 90 per cent of the total starch in 1 minute; of about 82 per cent of the grains and 96 per cent of the total starch in 3 minutes; of about 88 per cent of the grains and 99 per cent of the total starch in 5 minutes; and of all the starch except traces at the proximal end of a few grains in 15 minutes. These grains are very rapidly gelatinized with the exception of a few small grains and the proximal end, or proximal end and sides, of the larger grains. (Chart D 172.)

The reaction with *sulphuric acid* begins immediately. Complete gelatinization of a few grains occurs in 15 seconds and of a majority in 45 seconds; of about 90 per cent of the entire number of grains and 95 per cent of the total starch in 1 minute; of all of the grains excepting a small part of the margin of rare grains, or over 99 per cent of the total starch in 2 minutes; and of all of the starch in 2.5 minutes. (Chart D 173.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs of about 80 per cent of the entire number of grains and 90 per cent of the total starch in half a minute; of over 90 per cent of the grains and 99 per cent of the total starch in 1 minute; and of all the starch in 3 minutes. (Chart D 174.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs of over 80 per cent of the entire number of grains and 98 per cent of the total starch in 1 minute; of about 95 per cent of the grains and 99 per cent of the total starch in 2 minutes; of over 98 per cent of the grains and over 99 per cent of the total starch in 3 minutes; and of all the starch except minute parts of the proximal end of rare grains in 5 minutes. (Chart D 175.)

The reaction with *potassium iodide* begins immediately and a few grains are fully gelatinized in 30 seconds. Complete gelatinization occurs of about 90 per cent of the entire number of grains and 99 per cent of the total starch in 5 minutes, small parts of the proximal end being resistant; and of about 98 per cent of the grains and over 99 per cent of the total starch in 10 minutes, with little further advance in the process in 15 minutes. (Chart D 176.) A bubble appears frequently at the hilum and may be inclosed within a cleft, but before disappearing it may enlarge considerably. It is not so often inclosed as in *C. longifolium*, but a little more often than in *C. moorei*. The lamellæ become more distinct, more sharply defined than in *C. longifolium*, but not nearly so sharply defined as in *C. moorei*. Fissures of a similar character to those of both parents are formed, but they are not usually so deep and their definition is more quickly lost than in both parents. The mesial portion is disorganized with the appearance of less refractive granules than in both parents. The lamellæ of the distal margin are rarely disorganiuzed into linear granules, about as in *C. longifolium*, but much less frequently than in *C. moorei*. The gelatinization of a distal band previous to that of the main body found in the parents was not detected in the hybrid.

The gelatinized grains are swollen and little distorted, about as in *C. longifolium*, but slightly less than in *C. moorei*. They are usually completely gelatinized, though a narrow striated band may be found at the

proximal end and sides, but less frequently observed than in both parents. A group of brilliant granules are occasionally present in the area around the hilum and is less frequently observed than in *C. longifolium,* but more often seen than in *C. moorei.* They are somewhat more distorted than in both parents, but like them bear a general resemblance to the untreated grain.

The qualitative reactions exhibit a somewhat closer relationship in most of the grains to *C. moorei* than to *C. longifolium;* yet in some respects there is a decidedly closer relationship to *C. longifolium.*

The reaction with *potassium sulphocyanate* begins immediately and a few grains are fully gelatinized in 30 seconds. Complete gelatinization occurs of all of the grains except of the proximal end and sides of a few grains in 1 minute; of about 93 per cent of the entire number of grains and over 99 per cent of the total starch in 3 minutes; with little further advance in 5 minutes. (Chart D 177.)

A bubble, which expands to considerable size and is quite persistent in some grains, forms at the hilum. It expands to greater size and is much less frequently inclosed within an enlarged fissure than in *C. longifolium;* it enlarges more, is more persistent, and a little more frequently inclosed within an enlarged fissure than in *C. moorei.* The lamellæ frequently become more distinct than in *C. longifolium,* but less sharply defined than in *C. moorei.* Fissures proceeding from the hilum are formed in fewer grains than in both parents. The lamellæ are frequently disorganized through the mesial region with the appearance of but slightly refractive granules, much less refractive than in *C. longifolium* and slightly less than in *C. moorei;* although in a few grains the refractivity is closer to that in *C. longifolium* than in *C. moorei.* The resistant starch is located at the same area as in both parents.

The gelatinized grains are swollen and much distorted, more than in the parents, and they do not resemble the form of the untreated grain.

The qualitative reactions with the exception of those of a few grains, exhibit a closer relationship to *C. moorei* than to *C. longifolium.*

The reaction with *potassium sulphide* begins immediately and very few grains are fully gelatinized in 1 minute. Complete gelatinization occurs of about 26 per cent of the grains and 60 per cent of the total starch in 5 minutes; of about 39 per cent of the grains and 74 per cent of the total starch in 15 minutes; of about 43 per cent of the grains and 85 per cent of the total starch in 30 minutes; of about 45 per cent of the grains and 87 per cent of the total starch in 45 minutes; and of about 50 per cent of the grains and 88 per cent of the total starch in 60 minutes. (Chart D 178.) The *Crinum* characteristic of a narrow very resistant border at the proximal end is well shown in this starch by this reagent. (See also *C. longifolium* and *C. moorei.*)

At the hilum a bubble appears which enlarges more than in either parent. The lamellæ in the mesial portion become more sharply defined than in *C. longifolium,* but about as in *C. moorei.* The refractive border at the proximal end and sides is more quickly differentiated into lamellæ than in either parent. Much-branched fissures appear similar to those of the parents, but their definition is more quickly lost. The lamellæ of the mesial margin are quickly disorganized, usually without the appearance of granules, more frequently than in the parents. A refractive border at the proximal end and sides is the most resistant, as in the parents, and it is gelatinized without breaking into granules more frequently than in the parents. The grains are completely gelatinized, they are much swollen, and usually much distorted. They are considerably more distorted, and the individual grains are to a larger extent gelatinized, than in *C. longifolium,* but the mean distortion is about the same, and a narrow striated band is less frequently observed at the proximal end than in *C. moorei.* The gelatinized grains do not resemble the forms of the untreated grains. The qualitative reactions exhibit a closer relationship to *C. moorei* than to *C. longifolium.*

The reaction with *sodium hydroxide* begins immediately and many grains are fully gelatinized in 1 minute. Complete gelatinization occurs of about 90 per cent of the entire number of grains and 98 per cent of the total starch in 3 minutes; of about 95 per cent of the grains and over 99 per cent of the total starch in 5 minutes; and of all of the starch excepting traces of the proximal end in rare grains in 10 minutes. (Chart D 179.)

The reaction with *sodium sulphide* begins immediately and many grains are fully gelatinized in 1 minute. Complete gelatinization occurs of about 73 per cent of the grains and 97 per cent of the total starch in 5 minutes; of over 97 per cent of the grains and over 99 per cent of the total starch in 15 minutes; and of all the starch in 30 minutes. Only the proximal end of larger grains and the extreme margin of a few smaller grains exhibit resistant starch. (Chart D 180.)

At the hilum a bubble appears which expands to a large size, and is sometimes inclosed within an enlarged fissure. It enlarges about as in *C. longifolium,* but is less frequently inclosed within an enlarged cleft. It is more persistent, enlarges to greater size, and is a little more frequently inclosed within a cleft than in *C. moorei.* The lamellæ are more sharply defined and striated over the entire grain than in the parents, the relationship being less close to *C. longifolium* than *C. moorei.* Gelatinization occurs very rapidly without fissures being observed, but when present they are of the same character, though usually less sharply defined than in the parents. This less closely resembles *C. longifolium* than *C. moorei,* since the fissures of the latter are less frequent and deep than the former. The mesial region is more frequently gelatinized without the appearance of granules, but in occasional grains a few quite refractive brilliant scattered granules that are along the course of the fissures may appear. The granules in most grains are much less refractive than in *C. longifolium,* and there is greater variation, with the mean a little lower than in *C. moorei.* Either a refractive, distal, or marginal border is frequently present, not quite so often as in *C. longifolium,* and the lamellæ of which it is composed become more clearly defined than in *C. longifolium.* This border is more frequently seen, especially around the entire margin, than in *C. moorei.* It is gelatinized without the appearance of granules, as in the parents. The gelatinized grains are much swollen and distorted, so that they do not resemble the untreated grains, as in the parents.

The qualitative reactions, excepting on a minority of grains, much closer resemble those observed in *C. moorei* than in *C. longifolium.*

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs of about 44 per cent of the entire number of grains and 50 per cent of the total starch in 5 minutes; of about 92 per cent of the grains and 95 per cent of the total starch in 15 minutes; and of 99 per cent of the grains and over 99 per cent of the starch in 20 minutes. (Chart D 181.)

A bubble appears at the hilum and is sometimes inclosed within an enlarged fissure, less frequently than in *C. longifolium,* but more frequently than in *C. moorei.* The lamellæ become temporarily more distinct over a greater part of more grains than in both parents, which exhibits a less close relationship to *C. longifolium* than to *C. moorei.* A refractive border appears as has been noted for both parents. Gelatinization usually begins either at the distal corners or the distal margin; less frequently appearing first at the corners than in *C. longifolium,* but more frequently than in *C. moorei.* The reaction frequently follows at the proximal end after the distal border has been gelatinized, in such grains the most resistant portion is a band just distal to the hilum. Gelatinization occurs more quickly at the proximal end than in *C. longifolium,* about the same as in *C. moorei.* The reaction usually proceeds without the formation of fissures, much less frequently than in *C. longifolium,* and about the same as in *C. moorei.* The gelatinized grains are much swollen and distorted so that they do not resemble the untreated grain, about the same as in both parents. The qualitative reactions, with the exception of those of a minority of grains, exhibit a much closer relationship to *C. moorei* than to *C. longifolium.*

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs of about 50 per cent of the entire number of grains and 83 per cent of the total starch in 5 minutes; of about 85 per cent of the grains and over 98 per cent of the total starch in 15 minutes; and of 98 per cent of the grains and over 99 per cent of the total starch in 30 minutes. A very small area at the proximal end and sides is very resistant. (Chart D 182.)

The reaction with *uranium nitrate* begins immediately. Complete gelatinization occurs of 44 per cent of the entire number of grains and 83 per cent of the total starch in 5 minutes; of about 83 per cent of the entire number of grains and 99 per cent of the total starch in 15 minutes; of about 90 per cent of the grains and over 99 per cent of the total starch in 45 minutes; and of about the same percentage of each in 60 minutes. (Chart D 183.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs of about 61 per cent of the entire number of grains and 89 per cent of the total starch in 5 minutes; of about 95 per cent of the grains and over 99 per cent of the total starch in 15 minutes; of about 98 per cent of the grains and over 99 per cent of the total starch in 30 minutes; and of all the starch but traces in very rare grains in 60 minutes. (Chart D 184.)

The reaction with *cobalt nitrate* begins immediately. Complete gelatinization occurs of about 36 per cent of the entire number of grains and 68 per cent of the total starch in 5 minutes; of about 46 per cent of the grains and 78 per cent of the total starch in 15 minutes; of about 50 per cent of the grains and 85 per cent of the total starch in 30 minutes; of about 57 per cent of the grains and 89 per cent of the total starch in 45 minutes; of about 64 per cent of the grains and 93 per cent of the total starch in 60 minutes. (Chart D 185.) Gelatinization usually begins at the distal margin as in both parents; the proximal end and a small area of the sides and a few scattered grains of medium size are quite resistant.

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs of about 30 per cent of the entire number of grains and 82 per cent of the total starch in 5 minutes; of about 52 per cent of the grains and about 91 per cent of the total starch in 15 minutes; of about 65 per cent of the grains and 96 per cent of the total starch in 30 minutes; of about 80 per cent of the grains and 98 per cent of the starch in 45 minutes; and of about the same in each case in 60 minutes. (Chart D 186.) Gelatinization proceeds through the mesial portion along the course of well-defined fissures which are much less enlarged than in *C. longifolium,* but slightly more than in *C. moorei.* The distal margin undergoes complete gelatinization previous to that of the proximal end and sides as in both parents. Distention and fluting of the capsule at the distal margin occur less frequently than in either parent. The reactions are on the whole closer to those of *C. moorei.*

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs of about 22 per cent of the entire number of grains and 61 per cent of the total starch in 5 minutes; of about 48 per cent of the grains and 82 per cent of the total starch in 15 minutes; of about 64 per cent of the grains and 90 per cent of the total starch in 30 minutes; of about 77 per cent of the grains and 97 per cent of the total starch in 45 minutes; and of about the same in each case in 60 minutes. (Chart D 187.)

Gelatinization proceeds as in the parents, but the proximal end and sides are less resistant and the process is much less frequently accompanied with extension and frilling of the capsule at the distal margin than in the parents. The reactions are, on the whole, closer to those of *C. moorei.*

The reaction with *barium chloride* begins in a few grains immediately. Complete gelatinization occurs of about 2 per cent of the entire number of grains and 8 per cent of the total starch in 5 minutes; of about 11 per cent of the grains and 25 per cent of the total starch in 15 minutes; of about 18 per cent of the grains and 55 per cent of the total starch in 30 minutes; of about 22 per cent of the grains and 60 per cent of the total starch in 45 minutes; and of about 26 per cent of the grains and 66 per cent of the total starch in 60 minutes. (Chart D 188.)

The reaction with *mercuric chloride* begins immediately. Complete gelatinization occurs of 20 per cent of the entire number of grains and 62 per cent of the total starch in 5 minutes; of about 39 per cent of the grains and 92 per cent of the total starch in 15 minutes; of about 54 per cent of the grains and 96 per cent of the total starch in 30 minutes; of about 65 per cent of the grains and 97 per cent of the total starch in 45 minutes;

of about 69 per cent of the grains and 99 per cent of the total starch in 60 minutes. (Chart D 189.) The cleft at the hilum and fissures proceeding therefrom react as in the parents, but the enlargement and refractivity are more quickly lost. The proximal end of a number of grains, as well as rare entire grains, resist gelatinization, but they are less resistive than in the parents. The reactions are, on the whole, closer to those of *C. moorei*.

5. NERINE.

This genus includes 9 or 10 species of South American bulbous plants, the best known being *N. sarniensis* or the Guernsey lily. A number of the members of the genus have been known as belonging to other genera of Amaryllidaceæ, chiefly to *Amaryllis*. The starches from three sets of parent-stocks and hybrid-stocks were studied:

10. N. *crispa* Hort. (seed parent), *N. elegans (N. flexuosa* × *N. sarniensis* var. *rosea)* (pollen parent), *N. dainty maid* (hybrid), and *N. queen of roses* (hybrid).
11. *N. bowdeni* Hort. (seed parent), *N. sarniensis* var. *corusca major* Hort. (pollen parent), *N. giantess* (hybrid), and *N. abundance* (hybrid).
12. *N. sarniensis* var. *corusca major* Hort. (seed parent), *N. curvifolia* var. *fothergilli major* (*N. fothergilli major* Hort.) (pollen parent), and *N. glory of sarnia* (hybrid).

All of the specimens were obtained from the growers, Barr and Sons, London.

10. Starches of Nerine crispa, N. elegans, N. dainty maid, and N. queen of roses.

Nerine crispa (Seed Parent).

(Plate 6, figs. 31 and 34; Charts D 190 to D 210.)

Histologic Properties.

In *form* the grains are usually simple and isolated. No aggregates are noted and a very few compound grain of two types, of which the first has two hila set close together at the proximal end of a large grain, and the second of the two moderately large grains each with from 4 to 8 lamellæ surrounded by 1 or 2 common secondary lamellæ. The grains are usually moderately regular in form and any irregularity is due to the following causes: (1) Secondary lamellæ whose longitudinal axis are at varying angles with the longitudinal axis of the primary grains; (2) moderately large, rounded projections from the proximal or distal ends or sides; (3) rounded, shallow depressions in the margin at various points; (4) a small rather deep notch at the distal end; (5) a greater development of one part of the distal end or of one side than of the rest; (6) deviation of the longitudinal axis with a consequent curvature at the distal end or in the middle. The conspicuous forms are ovoid, usually rather broad, but sometimes slender; elongated elliptical with flattened distal end; and, among the small grains, round and nearly round. There are also plano-convex, triangular with rounded angles, modified pyriform, napiform, and spatulate. The proximal end of most of the forms is the larger and more rounded, and in only a few is the reverse the case.

The *hilum* when not fissured is a moderately distinct round spot. It is fissured in about 75 per cent of the grains and the fissures take the following forms: (1) A single, small, straight, transverse, or oblique line which is sometimes much branched; (2) small or large flying-bird; (3) T- or Y-shaped placed in the longitudinal and transverse axes or obliquely. In the compound grains the hila are sometimes separated by a cleft and may also have a common fissure remaining horizontally through both. The hilum is eccentric from 0.4 to 0.2, usually, 0.26 of the longitudinal axis.

The *lamellæ* are very distinct, usually rather fine lines, which when near the hilum are circular and continuous, but become discontinuous near the distal end and have the form of the outline of the grain, the form being somewhat modified in certain cases. In a large number of grains the lamellæ are fine near the distal end and not so fine near the hilum, in others they are of equal size in almost all parts of the grain, and in still others they are finer near the hilum and not so fine near the distal margin. There is characteristically one very distinct, coarse, continuous lamella which may be near the hilum, or, rarely, near the margin, but is usually about midway between the hilum and the margin. The number counted on the larger grains varies from 20 to 40, usually 34.

The *size* of the grains varies from the smaller which are 6 by 6μ to the larger elongated forms which are 50 by 26μ, rarely 56 by 30μ, and the larger broader forms which are 50 by 36μ in length and breadth. The common sizes are 34 by 22μ and 34 by 28μ, respectively.

Polariscopic Properties.

The *figure* is slightly to very eccentric, distinct, and usually clear-cut. The lines are usually fine and intersect obliquely, but in a moderate number of grains they intersect at right angles. They are sometimes straight but equally as often bent, and occasionally are bisected. Double figures are not very numerous but do occur.

The *degree of polarization* is moderate to very high (value 85). It varies in different grains, a moderate number having a moderately high, a few having a very high, and the majority having a high polarization. Occasionally moderate variation in polarization in the same aspect of a given grain is present.

With *selenite* the quadrants are usually well defined, often somewhat irregular in shape, and always unequal in size. The colors are usually pure, the yellow less often pure than the blue. A few of the grains have a greenish tinge.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains color a moderate blue with a slight tinge of violet (value 45) which very rapidly becomes deep to very deep, the bluish tint increasing. With 0.125 per cent Lugol's solution the grains color a moderate to light blue with a slight tinge of violet, which deepens rapidly, becoming more blue, the depth varying from moderately deep in most grains to very deep in a few small grains. After heating in water until the grains are gelatinized, and then adding a 2 per cent Lugol's solution, the *grains* color a moderately deep to very deep indigo-blue, the capsules usually can not be distinguished, but if so are colored violet; the *solution* colors a moderately deep indigo-blue. If the preparation is boiled for 2 minutes, and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* color light to deep indigo-blue; the *capsules*, of

which not all can be distinguished, a pure violet; and the *solution* a deep indigo-blue.

Aniline Reactions.

With *gentian violet* the grains stain very lightly at once, and in half an hour they are light to moderately colored (value 40). Some of the grains are more altered than others, and many of the individual grains are more stained at the distal end than elsewhere.

With *safranin* the grains stain very lightly at once, and in half an hour they are moderately colored (value 50). Some of the grains are more affected than others, and many of the individual grains are more stained at the distal end than elsewhere.

Temperature Reactions.

The majority of the grains are gelatinized at 64° to 65.5° C., and all at 70° to 71.5° C., mean 70.7° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in a few grains immediately. Complete gelatinization occurs in about 8 per cent of the entire number of grains and 12 per cent of the total starch in 5 minutes; in about 33 per cent of the grains and 37 per cent of the total starch in 15 minutes; in about 62 per cent of the grains and 65 per cent of the total starch in 30 minutes; in about 64 per cent of the grains and 67 per cent of the total starch in 45 minutes; in about 66 per cent of the grains and 72 per cent of the total starch in 60 minutes. (Chart D 190.)

The hilum becomes distinct and a small bubble is often formed there. The lamellæ, also, are moderately distinct, especially those which are less fine than the majority. A broad, very refractive band (broader at the distal end) is formed about the margins of the grains. Gelatinization begins usually first at the distal end and then, quickly, at the proximal end, or, less frequently, at the proximal and then at the distal end, or, rarely, at the distal end alone. Gelatinization progresses smoothly, although with some invasion by fissures and breaking off of fragments of the ungelatinized material and separation and gelatinization serially of lamellæ until the most resistant part, just distal to the hilum, is reached; there the margin on either side is gelatinized more rapidly than the inner portion which also is finally gelatinized with considerable folding and invagination of the capsule. In some of the less-resistant grains, this resistant portion is divided by a refractive furrow or fissure proceeding from the hilum which splits it into two parts that gelatinize separately. The gelatinized grains are very large, very much distorted, especially at the distal end, and do not retain much of the form of the untreated grain.

The reaction with *chromic acid* begins in rare grains immediately. Complete gelatinization occurs in much less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 0.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 36 per cent of the total starch in 30 minutes; in about 46 per cent of the grains and 90 per cent of the total starch in 45 minutes; in about 75 per cent of the grains and 95 per cent of the total starch in 60 minutes. (Chart D 191.)

The reaction with *pyrogallic acid* begins in rare grains immediately. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes. (Chart D 192.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 19 per cent of the entire number of grains and 62 per cent of the total starch in 5 minutes; in about 58 per cent of the grains and 80 per cent of the total starch in 15 minutes; in about 80 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 90 per cent of the grains and 99 per cent of the total starch in 45 minutes; in about 92 per cent of the grains and in more than 99 per cent of the total starch in 60 minutes. (Chart D 193.)

The hilum becomes very distinct and the lamellæ also become very distinct and remain so, particularly at the proximal end, throughout the greater part of the reaction. Gelatinization begins at the hilum which enlarges somewhat. Two refractive fissures extend distally from either side of the hilum, branching as they near the distal margin, and the material on either side along their courses becomes transparent and then gelatinous while the whole grain enlarges somewhat and becomes more nearly transparent, but retains its structure. Next, regular cracks invade the 2 or 3 marginal lamellæ and divide them into coarse granules. The hilum also begins to enlarge steadily and the material immediately surrounding it, which has become nearly transparent, is divided and subdivided by irregular fissures into rather fine granules. In the meantime the rest of the grain excepting the proximal end is completely gelatinized and the grain swells considerably, and the granules around the hilum are widely separated and scattered throughout the proximal end and often persist there after the rest of the grain is gelatinized. The lamellæ at the proximal end form a refractive, resistant band at the margin which is invaded by cracks from the margin and then gelatinized from the margin inward. The gelatinized grains are thin-walled and somewhat distorted and do not show much of the form of the untreated grain.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 67 per cent of the grains and 85 per cent of the total starch in 1 minute; in about 98 per cent of the grains and 99 per cent of the total starch in 3 minutes; in 100 per cent of the grains and total starch in 5 minutes. (Chart D 194.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 63 per cent of the entire number of grains and 90 per cent of the total starch in 5 minutes; in about 91 per cent of the grains and more than 99 per cent of the total starch in 15 minutes. (Chart D 195.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 88 per cent of the entire number of grains and 97 per cent of the total starch in 1 minute; in about 95 per cent of the grains and 99 per cent of the total starch in 3 minutes; in about 97 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 196.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 0.5 per

cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 4 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 9 per cent of the total starch in 30 minutes; in about 1 per cent of the grains and 17 per cent of the total starch in 45 minutes; in about 3 per cent of the grains and 28 per cent of the total starch in 60 minutes. (Chart D 197.)

The hilum is very distinct, and the lamellæ also are very distinct and remain so during the greater part of the reaction. Gelatinization begins at the hilum which enlarges slowly, while from either side of the hilum two refractive fissures extend distally. The starch immediately surrounding the hilum is, in some grains, divided by irregular fissures into rather coarse granules, and that part of the grain lying between the two refractive fissures before mentioned becomes finely granular and rather hyaline in appearance, while the more resistant starch at the proximal end and sides forms a narrow lamellated band which is invaded by cracks from the margin and thus divided off into rather fine granules that gradually become thinner and more nearly transparent from the margin inward and, in those grains in which gelatinization is completed, finally disappear leaving only the thin capsule. The gelatinized grains are large and somewhat distorted but retain some of the form of the untreated grain.

The reaction with *potassium sulphocyanate* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 10 per cent of the total starch in 15 minutes; in about 21 per cent of the grains and 42 per cent of the total starch in 30 minutes; in about 38 per cent of the grains and 61 per cent of the total starch in 45 minutes; in about 54 per cent of the grains and 70 per cent of the total starch in 60 minutes. (Chart D 198.)

The hilum becomes very distinct, and no bubble is observed to form there during the reaction. The lamellæ are also distinct and remain so during the greater part of the reaction. Before gelatinization begins two lines or fissures, in the interior of the grain, are observed to extend from either side of the hilum nearly to the distal margin, and the material between these two lines becomes lighter and more refractive in appearance. Gelatinization begins at the hilum, which enlarges slowly, the two fissures already mentioned, becoming wider at the same time, are seen to divide into many fine branches as they near the distal end and divide the portion between them into many fine granules which become more and more nearly transparent as the reaction advances. As the hilum continues to enlarge several other coarse fissures penetrate this material and divide it into several pyramidal portions, from the sides of which feathery spicules are separated off and gelatinized. The grain meanwhile enlarges and the more resistant starch at the proximal end and sides forms a thick non-lamellated, non-striated band, which as swelling and gelatinization continue becomes progressively thinner and more nearly transparent, until all the material is gelatinized and only the thin capsule is left. The gelatinized grains are moderately large and thin-walled and are somewhat distinct, especially at the distal end, but they retain some resemblance to the form of the untreated grain.

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 22 per cent of the entire number of grains and 60 per cent of the total starch in 5 minutes; in about 66 per cent of the grains and 88 per cent of the total starch in 15 minutes; in about 73 per cent of the grains and 93 per cent of the total starch in 30 minutes; in about 78 per cent of the grains and 95 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 199.)

The hilum and lamellæ are very distinct, and the lamellæ, especially at the proximal end, remain so during the greater part of the reaction. Gelatinization begins at the hilum which enlarges somewhat, and at the same time 2 refractive fissures extend from the hilum toward the distal end, branching considerably as they near the margin. As the hilum continues to enlarge the material immediately surrounding it is divided by irregular fissures into rather coarse granules, and the portion included between the 2 fissures before mentioned becomes more hyaline in appearance and then finely granular and is gelatinized from the hilum outward. In the meantime the more-resistant starch at the proximal end forms a thick, lamellated marginal band which later becomes striated and then divided into coarse granules, and after the rest of the grains is gelatinized this becomes gelatinized, usually from the margin inward, leaving the granules originally found about the hilum till the last. In a few grains, the capsule is dissolved at from four to nine different points and the grain is slit at these points nearly to the center. The gelatinized grains are large and somewhat distorted but retain some resemblance to the form of the untreated grain.

The reaction with *sodium hydroxide* begins in a few grains in half a minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 30 minutes; in about 4 per cent of the grains and 6 per cent of the total starch in 45 minutes; in about 7 per cent of the grains and 10 per cent of the total starch in 60 minutes. (Chart D 200.)

The reaction with *sodium sulphide* begins in rare grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; slight advance in 15 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 30 minutes; slight advance in 45 minutes; in about 2 per cent of the grains and 4 per cent of the total starch in 60 minutes. (Chart D 201.)

The reaction with *sodium salicylate* begins in 2 minutes. Complete gelatinization occurs in about 17 per cent of the entire number of grains and 42 per cent of the total starch in 5 minutes; in about 70 per cent of the grains and 82 per cent of the total starch in 10 minutes; in about 95 per cent of the grains and 98 per cent of the total starch in 15 minutes. (Chart D 202.)

This reaction was repeated because it is so much slower at 5 minutes than in the other species. The most marked difference with this reagent is found at 5 minutes. The permeability of the capsule varies—that of *N. crispa*

apparently being the most resistant. The capsule of the gelatinized grain of this species appears heavier and less distorted than that of the species studied. It is to be noted that when the reaction in this species becomes started, it is more rapid than in *N. bowdeni,* etc.

The hilum is distinct, and a bubble is usually formed there. The lamellæ become distinct, especially those which are not so fine as the greater number. A narrow and not very refractive band is formed about the margins of the grains. Gelatinization in most of the grains begins first at several points on the distal margin and then at the hilum and proximal end, and, in others, first at the hilum and proximal end and then at the distal margin. Gelatinization progresses smoothly from the proximal end and from the distal end by serial separation and gelatinization of the lamellæ and in most of the grains continues so until a part of the grain midway between the hilum and the distal end is reached, then the margin on either side is first rapidly gelatinized, and then the central material, accompanied by a deep invagination of the previously distended gelatinized proximal portion and of the rather less distended gelatinized distal portion, a process which leaves a crumpled mass to represent the completely gelatinized grain. In other grains gelatinization proceeds smoothly from the two ends until the hilum is reached from the proximal end, then a refractive furrow or central fissure extends rapidly from the hilum distally, and as the portion along the course of this fissure gelatinizes the more resistant material at the sides and margin is split into two pieces, which then rapidly gelatinize. The gelatinized grains are very large and much distorted and do not show any resemblance to the untreated grain.

The reaction with *calcium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 4 per cent of the total starch in 30 minutes; in about 3 per cent of the grains and 8 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 10 per cent of the total starch in 60 minutes. (Chart D 203.)

The reaction with *uranium nitrate* begins in 1 minute. Complete gelatinization occurs in 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 3 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 9 per cent of the total starch in 30 minutes; in about 6 per cent of the grains and 19 per cent of the total starch in 45 minutes; in about 18 per cent of the grains and 28 per cent of the total starch in 60 minutes. (Chart D 204.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 58 per cent of the total starch in 5 minutes; in about 55 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 86 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 92 per cent of the grains and 96 per cent of the total starch in 45 minutes; in about 93 per cent of the grains and 99 per cent of the total starch in 60 minutes. (Chart D 205.)

The reaction with *cobalt nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; very little advance in 15 and 30 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 45 minutes; very little if any further advance in 60 minutes. (Chart D 206.)

The reaction with *copper nitrate* begins in a few grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 14 per cent of the total starch in 30 minutes; in about 10 per cent of the grains and 22 per cent of the total starch in 45 minutes; in about 14 per cent of the grains and 25 per cent of the total starch in 60 minutes. (Chart D 207.)

The reaction with *cupric chloride* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 15 minutes; little if any further advance in 30, 45, and 60 minutes. (Chart D 208.)

The reaction with *barium chloride* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; little if any further progress in 30, 45, and 60 minutes. (Chart D 209.)

The reaction with *mercuric chloride* begins in a few grains in 2 minutes. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; slight progress in 15 minutes; in about 2 per cent of the grains and 5 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes. (Chart D 210.)

Nerine elegans (Pollen Parent).

(Plate 6, figs. 32 and 35; Charts D 190 to D 210.)

Histologic Properties.

In *form* the grains are usually simple and isolated, but there are a few aggregates, linearly arranged, which are not noted in *N. crispa,* and a few compound grains, which have either 2 components as in *N. crispa,* or 3 or even 4, which are noted in that starch. The grains are more regular than in *N. crispa* and any irregularities which occur are due to the following causes: (1) Greater development of one part of the distal end or of one side than of the rest; (2) protuberances, which are not so large as in *N. crispa;* (3) a small deep notch in the distal margin, which is more common than in *N. crispa;* (4) a deviation of the longitudinal axis with consequent bending of the grain; (5) secondary sets of lamellæ whose longitudinal axes are at varying angles with those of the primary set The conspicuous forms are ovoid and elongated elliptical, even among the small grains. There are also triangular with rounded angles, irregularly quadrilateral with rounded angles, pyriform, and nearly round shapes. In the grains of *N. elegans* usually the proximal end is smaller than the distal end or both ends are of equal size, and only occasionally is the distal end the smaller as in the majority of the grains of *N. crispa.*

The grains of this starch differ from those of *N. crispa,* in having a larger number of components in the compound grains, in the presence of aggregates, in being more regular in form, in being somewhat narrower in form, and in having the proximal end smaller than the distal end in the majority of grains.

The *hilum* is not so distinct as in *N. crispa,* and is very much less apt to be fissured. When fissuring does occur it takes the following forms: (1) A small straight transverse or oblique line which may be branched; (2) a small flying-bird. The hilum is eccentric from 0.42 to 0.17, usually 0.23, of the longitudinal axis, slightly more than in *N. crispa.*

The *lamellæ* are, as a rule, finer than those of *N. crispa* and therefore not so distinct, and as a rule are not so fine at the distal end as near the hilum, whereas in *N. crispa* the number of grains in which they are not so fine at the hilum as at the distal end about equals the number of grains in which the reverse is true. There is one very distinct, continuous, coarse lamella on nearly every grain, as in *N. crispa.* The number counted on the larger grains varies from 20 to 35, usually 30, somewhat less than in *N. crispa.*

The *size* of the grains varies from the smaller which are 4 by 4μ to the larger more slender elongated forms which are 46 by 24μ, and the larger broader forms 46 by 30μ, in length and breadth. The common sizes are 30 by 20μ and 30 by 24μ. The sizes generally are less than in *N. crispa.*

Polariscopic Properties.

The *figure* is slightly to very eccentric, usually somewhat more eccentric than in *N. crispa,* distinct and more apt to be clear-cut than in *N. crispa.* The lines are more often fine than in *N. crispa* and usually intersect obliquely, and in fewer grains at right angles than in *N. crispa.* They are more often straight than in *N. crispa,* but are sometimes bent as in those grains and very rarely bisected. Double figures are rare as in *N. crispa.*

The *degree of polarization* is moderate to very high (value 80), less than in *N. crispa.* It varies in different grains and fewer grains have a very high and high polarization than in *N. crispa.* Occasionally, as in *N. crispa,* moderate variation in polarization in the same aspect of a given grain is present.

With *selenite* the quadrants are usually well defined and more unequal in size, but less irregular in shape than in *N. crispa.* The colors are usually pure but are not so often pure as in *N. crispa,* and the yellow is less often pure than the blue. A very few of the grains have a greenish tinge.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains color a moderate blue with a tinge of violet (value 55), deeper than in *N. crispa,* and the color becomes more rapidly deep to very deep than in *N. crispa.* With 0.125 per cent Lugol's solution the grains color a moderate to light blue with somewhat more violet than in *N. crispa,* and the color deepens somewhat more rapidly than in *N. crispa* to a moderately deep to deep degree. After heating in water until the grains are gelatinized, and then adding a 2 per cent Lugol's solution, the *grains* are colored a moderate to very deep indigo, not so deep as in *N. crispa;* the *capsules* are usually indistinguishable from the contents; and the *solution* colors a deeper indigo-blue than in *N. crispa.* If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* color light to moderately deep blue, less than in *N. crispa,* the capsules a pure violet as in *N. crispa,* and the *solution* a deeper indigo-blue than in *N. crispa.*

Aniline Reactions.

With *gentian violet* the grains color very lightly at once, and in half an hour they are light to moderately colored (value 35), lighter than in *N. crispa.* As in *N. crispa,* some grains are more colored than others, and many of the individual grains are more colored at the distal end than elsewhere.

With *safranin* the grains color very lightly at once, and in half an hour they are moderately colored (value 45), but less than in *N. crispa.* As in *N. crispa,* some grains are more colored than others, and many of the individual grains are more colored at the distal end than elsewhere.

Temperature Reactions.

The majority of the grains are gelatinized at 68.5° to 70° C., and in all at 75° to 76.9° C., mean 75.9° C., or 5.2° C. higher than in *N. crispa.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 9 per cent of the entire number of grains and 15 per cent of the total starch in 5 minutes; in about 84 per cent of the grains and 89 per cent of the total starch in 15 minutes; in about 96 per cent of the grains and 97 per cent of the total starch in 30 minutes. (Chart D 190.)

The hilum as in *N. crispa* is distinct, and a bubble is much less frequently formed there than in those grains. The lamellæ are not quite so distinct as in *N. crispa.* A broad refractive band, which is much more refractive than in *N. crispa,* is quickly formed about the margins of the grains. Gelatinization begins usually at the proximal end and this may be quickly followed (but is usually not) by gelatinization of the distal end, but in some grains it begins first at the distal end, then at the proximal end, or it may begin at and continue only from the distal end. Gelatinization progresses more smoothly than in *N. crispa* with less invasion by fissures and separation of gelatinized from ungelatinized starch, and the most resistant portion is usually found much nearer the distal margin, than in *N. crispa.* The gelatinized grains are large and considerably distorted but not so distorted as in *N. crispa.*

The reaction with *chromic acid* begins in rare grains immediately. Complete gelatinization occurs in much less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in still less than 0.5 per cent of the grains and 3 per cent of the total starch in 15 minutes; still in less than 0.5 per cent of the grains but in 50 per cent of the total starch in 30 minutes; in about 68 per cent of the grains and 92 per cent of the total starch in 45 minutes; in more than 99 per cent of the grains and total starch in 60 minutes. (Chart D 191.)

The reaction with *pyrogallic acid* begins in rare grains immediately. Complete gelatinization occurs in

less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; slight advance in 15 and 30 minutes; in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 192.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 16 per cent of the entire number of grains and 88 per cent of the total starch in 5 minutes; in about 77 per cent of the grains and 96 per cent of the total starch in 15 minutes; in about 94 per cent of the grains and 99 per cent of the total starch in 30 minutes. (Chart D 193.) The hilum and lamellæ are not so distinct as in *N. crispa*, and the lamellæ at the distal end while differing from those of the grains of *N. crispa* remain distinct longer than at the proximal end. Gelatinization as in *N. crispa* begins at the hilum, but in these grains the proximal end is usually less resistant than the distal end, and when the hilum and the grain enlarge it is first at the proximal end and later at the distal end. There are few if any granules formed of the mass immediately surrounding the hilum; and the marginal band which extends completely around the grain, instead of being only at the proximal end as in *N. crispa,* is not invaded by cracks and so divided into granules as in those grains, but remains as a homogeneous-looking band which becomes progressively thinner and more nearly transparent and finally is gelatinized, leaving only the thin capsule. The gelatinized grains are large and thin-walled but not so distinct as in *N. crispa,* and retain more of the form of the untreated grain.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 77 per cent of the entire number of grains and 90 per cent of the total starch in 1 minute; in about 98 per cent of the grains and more than 99 per cent of the total starch in 3 minutes; in about 99 per cent of the grains and more than 99 per cent of the total starch in 5 minutes. (Chart D 194.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 55 per cent of the entire number of grains and 90 per cent of the total starch in 5 minutes; in about 90 per cent of the grains and in more than 99 per cent of the total starch in 15 minutes. (Chart D 195.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 95 per cent of the entire number of grains and 98 per cent of the total starch in 1 minute; in about 98 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes, very little change in 15 minutes. (Chart D 196.)

The reaction with *potassium iodide* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in less than 0.5 per cent of the grains and 2 per cent of the total starch in 30 minutes; in about 0.5 per cent of the grains and 3 per cent of the total starch in 45 minutes; in about 2 per cent of the grains and 8 per cent of the total starch in 60 minutes. (Chart D 197.) The hilum and lamellæ are not so distinct as in *N. crispa,* and gelatinization as in *N. crispa* begins at the hilum, which enlarges slowly at the same time that 2 refractive fissures extend distally. The process is much the same as that described under *N. crispa,* except that fissuration and granulation of the starch immediately surrounding the hilum are much more common in these grains than in *N. crispa* and the material included between the 2 refractive fissures already mentioned is often divided into distinct, rather coarse granules by branches from the fissures. No grains are noted in which one of the fissures turn to one side rather than to the distal margin such as are noted in *N. crispa.* The gelatinized grains are large and somewhat more distorted than those of *N. crispa.*

The reaction with *potassium sulphocyanate* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 10 per cent of the total starch in 15 minutes; in about 15 per cent of the grains and 30 per cent of the total starch in 30 minutes; in about 18 per cent of the grains and 40 per cent of the total starch in 45 minutes; in about 22 per cent of the grains and 55 per cent of the total starch in 60 minutes. (Chart D 198.) The hilum is distinct, but not as distinct as in *N. crispa,* and the lamellæ are moderately distinct and remain so during the greater part of the reaction, but are not so distinct as in *N. crispa.* Before gelatinization begins two fissures in the interior of the grain are seen to extend from the hilum nearly to the distal margin as in *N. crispa,* but the material between them does not become lighter and more refractive in appearance as in *N. crispa.* Gelatinization as in *N. crispa* begins at the hilum, but the proximal starch is usually the first to be gelatinized rather than the distal material as in *N. crispa.* After the hilum has enlarged in the direction of the proximal end and most of the proximal material is gelatinized, the distal portion becomes rather refractive and assumes a pitted appearance and then gelatinizes from the hilum distally. The last part of the grain to be gelatinized is the portion on either side of the distal margin. The gelatinized grains are moderately large and as distorted as those of *N. crispa.*

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 21 per cent of the entire number of grains and 62 per cent of the total starch in 5 minutes; in about 69 per cent of the grains and 91 per cent of the total starch in 15 minutes; in about 81 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 84 per cent of the grains and 97 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 199.) The hilum and lamellæ are less distinct than in *N. crispa.* Gelatinization, as in *N. crispa,* begins at the hilum. As the proximal end is usually the least resistant part of the grain it differs in this respect from those of *N. crispa.* The hilum and grain both swell in this direction first, and the portion here is gelatinized comparatively quickly without the formation of granules. Then the distal material, which has meanwhile lost its lamellated appearance and becomes homogeneous looking, is gelatinized from the hilum outwards without any discernible fissuring until only a nearly transparent mass remains at the distal margin, and this may present a

striated appearance. In a few grains the reverse is the case and the least resistant part of the grain is the distal portion as in *N. crispa,* but even in these grains the reaction takes place without much less fissuring and less formation of granules than in *N. crispa.* There are rather more grains than in *N. crispa* in which dissolution of the capsule occurs. The gelatinized grains are large and thin-walled and less distorted than those of *N. crispa.*

The reaction with *sodium hydroxide* begins in a few grains in half a minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 8 per cent of the total starch in 30 minutes; in about 6 per cent of the grains and 12 per cent of the total starch in 45 minutes; in about 10 per cent of the grains and 15 per cent of the total starch in 60 minutes. (Chart D 200.)

The reaction with *sodium sulphide* begins in a few grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about the same percentage of the grains and 3 per cent of the total starch in 15 minutes; slight advance in 30 minutes; in about 1 per cent of the grains and 4 per cent of the total starch in 45 minutes; in about 2 per cent of the grains and 5 per cent of the total starch in 60 minutes. (Chart D 201.)

The reaction with *sodium salicylate* begins in half a minute. Complete gelatinization occurs in about 75 per cent of the entire number of grains and 88 per cent of the total starch in 5 minutes; in about 99 per cent of the grains and in more than 99 per cent of the total starch in 10 minutes. (Chart D 202.) The hilum is as distinct as in *N. crispa,* but no bubble is formed there until after gelatinization begins. The lamellæ are, as a rule, not so distinct as in *N. crispa.* A narrow refractive band, which is more refractive than in *N. crispa,* is quickly formed about the margins of the grains. Gelatinization begins, almost invariably, first at the proximal end, and then, after about half of the grain has been gelatinized, at the distal end, but occasionally first at the distal end. Gelatinization proceeds smoothly from the proximal end and the hilum swells, and a bubble is formed there which first swells and then shrinks and disappears, until, as has been stated, half of the grain has gelatinized; at this point in the reaction, gelatinization begins at the distal end and proceeds first rapidly about the margin to meet the gelatinization from the proximal side. Then, as in *N. crispa,* the remaining inner ungelatinized starch is quickly gelatinized with invagination of both proximal and distal ends, not so great, however, as in *N. crispa.* In the few grains in which gelatinization starts first at the distal end, it soon starts also at the proximal end and the process is the same as that described under *N. crispa.* The gelatinized grains are large, but not so much distorted as in *N. crispa,* and show a little resemblance to the form of the untreated grain.

The reaction with *calcium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; slight advance in 30 minutes; in about 1 per cent of the grains and 5 per cent of the total starch in 45 minutes; in about 1 per cent of the grains and 8 per cent of the total starch in 60 minutes. (Chart D 203.)

The reaction with *uranium nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and 3 per cent of the total starch in 15 minutes; in less than 0.5 per cent of the grains and 9 per cent of the total starch in 30 minutes; in about 1 per cent of the grains and 11 per cent of the total starch in 45 minutes; in about 2 per cent of the grains and 14 per cent of the total starch in 60 minutes. (Chart D 204.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 15 per cent of the entire number of grains and 60 per cent of the total starch in 5 minutes; in about 80 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 90 per cent of the grains and 98 per cent of the total starch in 30 minutes; in about 92 per cent of the grains and 99 per cent of the total starch in 45 minutes; in about 95 per cent of the grains and in more than 99 per cent of the total starch in 60 minutes. (Chart D 205.)

The reaction with *cobalt nitrate* begins in rare grains in half a minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; very slight advance in 15 and 30 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 206.)

The reaction with *copper nitrate* begins in a few grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and total starch in 15 minutes; in 0.5 per cent of the grains and 2 per cent of the total starch in 30 minutes; in about 2 per cent of the grains and 6 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 9 per cent of the total starch in 60 minutes. (Chart D 207.)

The reaction with *cupric chloride* begins in a few grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the grains and 1 per cent of the total starch in 5 minutes; very little advance in 15 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes. (Chart D 208.)

The reaction with *barium chloride* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; little if any further advance in 30, 45, and 60 minutes, respectively. (Chart D 209.)

The reaction with *mercuric chloride* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes;

slight advance in 30 minutes; in about 0.5 per cent of the grains and 3 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 210.)

Nerine dainty maid (Hybrid).

(Plate 6, fig. 33; Charts D 190 to D 210.)

Histologic Properties.

In *form* the grains are usually simple and isolated as in the parents, but there are as many aggregates and of the same character as in *N. crispa*. The grains are as irregular in form as in *N. crispa* and the irregularities are due to the same causes; it is to be noted, however, that irregularities due to a greater development of one part of the distal end or to one side, and to deviation of the longitudinal axis, are not so common as in *N. crispa*. The conspicuous forms are ovoid and elliptical with flattened distal end, and among the smaller grains broad ovoid, round, and nearly round. There are also triangular, pyriform, and irregularly quadrilateral. Most of the grains resemble *N. crispa* as to the relative size of the proximal and distal ends, but there are more with the proximal end smaller than the distal end than in *N. crispa*. In form this hybrid more closely resembles *N. crispa* than *N. elegans*.

The *hilum* is as distinct as in *N. crispa* but rarely fissured, and therefore more like *N. elegans*. It is eccentric from 0.43 to 0.19, usually 0.24, of the longitudinal axis, close to *N. elegans*. In character and eccentricity the hilum more closely resembles *N. elegans* than *N. crispa*.

The *lamellæ* are finer than in either parent and, hence, in this respect more like *N. elegans*, otherwise (in character and arrangement) they resemble *N. crispa*. The number counted on the grains varies from 16 to 30, usually 26, less than in either parent, but closer to *N. elegans*.

The *size* of the grains varies from the smaller which are 6 by 6μ, to the larger more slender forms which are 43 by 26μ, and the larger broader forms which are 46 by 38μ, rarely 46 by 40μ, in length and breadth. The common sizes are 32 by 20μ and 32 by 24μ respectively. In size *N. dainty maid* is somewhat closer to *N. elegans* than to *N. crispa*.

Polariscopic Properties.

The *figure* is slightly to very eccentric, usually as eccentric as in *N. crispa*, and as distinct and clear-cut as in *N. elegans*. The lines are usually fine and are less irregular than in *N. crispa*, but more than in *N. elegans*.

The *degree of polarization* is moderate to very high (value 80), the same as in *N. elegans*, and less than in *N. crispa*. There are very few grains of a very high polarization, and fewer of a high degree of polarization than in *N. crispa*, but the same as in *N. elegans*.

With *selenite* the quadrants are usually well defined as in *N. elegans* and unequal in size, but less irregular in shape than in *N. crispa*, but more than in *N. elegans*. The colors are less often pure than in *N. crispa*, but the same as in *N. elegans*.

In degree of polarization, character of the figure, and appearances with selenite, *N. dainty maid* is closer to *N. elegans* than to *N. crispa*.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains color a moderate to deep blue with a tinge of violet (value 60), deeper than in either parent, but closer to *N. elegans;* and the color very rapidly becomes deep to very deep as in *N. elegans*. With 0.125 per cent Lugol's solution the grains color a moderate to light blue with a tinge of violet, more than in either parent, and the color deepens as rapidly as in *N. elegans* to a moderately deep to deep. After heating in water until the grains are gelatinized and then adding a 2 per cent Lugol's solution, the *grains* color a moderate to very deep indigo, as deep as in *N. elegans;* the capsules are usually indistinguishable from the grains; and the *solution* colors a deep indigo-blue as in *N. elegans*. If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution, the grain-residues color light to moderately deep blue, the same as in *N. elegans*, the *capsules* a pure violet as in the parents, and the *solution* a somewhat deeper indigo than in *N. elegans*. Qualitatively and quantitatively the reactions with iodine are closer to those of *N. elegans*.

Aniline Reactions.

With *gentian violet* the grains color very lightly at once, and in half an hour they are lightly to moderately colored (value 35), the same as *N. elegans*. As in the parents, there is inequality of coloring of the different grains and in parts of individual grains.

With *safranin* the grains color very lightly at once and in half an hour they are moderately colored (value 45), the same as *N. elegans*. As in the parents there is inequality of coloring between the different grains, and in individual grains.

In the reaction to aniline stains *N. dainty maid* shows a closer relationship to *N. elegans* than to *N. crispa*.

Temperature Reactions.

The majority of the grains are gelatinized at 69° to 70.5° C., and all at 72.5° to 73.8° C., mean 73.2° C., or 2.5° higher than in *N. crispa*, and 2.7° lower than in *N. elegans*. The temperature of gelatinization of *N. dainty maid* is midway between that of *N. crispa* and *N. elegans*.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in a few grains immediately. Complete gelatinization occurs in about 8 per cent of the entire number of grains and 13 per cent of the total starch in 5 minutes; in about 69 per cent of the grains and 77 per cent of the total starch in 15 minutes; in about 85 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 88 per cent of the grains and 92 per cent of the total starch in 45 minutes; in about 90 per cent of the grains and 95 per cent of the total starch in 60 minutes. (Chart D 190.)

The hilum, as in the parents, is distinct, and there are very few bubbles at this part, as in *N. elegans*. The lamellæ are as distinct as in *N. crispa*, and a broad refractive band which is as refractive as in *N. crispa* is formed about the margins of the grains. Gelatinization begins usually at the proximal end as in *N. elegans*, but there are some grains in which it begins as in *N. crispa*. The progress of gelatinization is the same as in *N. elegans*.

The gelatinized grains are larger and more distorted than in *N. elegans* but less distorted than in *N. crispa*. *N. dainty maid* shows qualitatively a closer relationship to *N. elegans* than to *N. crispa*.

The reaction with *chromic acid* begins in rare grains immediately. Complete gelatinization occurs in much less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; still in less than 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 33 per cent of the total starch in 30 minutes; in about 62 per cent of the grains and 83 per cent of the total starch in 45 minutes; in about 91 per cent of the grains and 95 per cent of the total starch in 60 minutes. (Chart D 191.)

The reaction with *pyrogallic acid* begins in rare grains immediately. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; little if any further advance is made in 15, 30, 45, and 60 minutes, respectively. (Chart D 192.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 23 per cent of the entire number of grains and 72 per cent of the total starch in 5 minutes; in about 64 per cent of the grains and 83 per cent of the total starch in 15 minutes; in about 85 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 90 per cent of the grains and 96 per cent of the total starch in 45 minutes; in about 91 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 193.) The hilum and lamellæ are distinct as in *N. elegans*. Gelatinization as in the parents begins at the hilum, and the proximal end as in *N. elegans* is usually less resistant than the distal end of the grain; there are, however, some grains in which as in *N. crispa* the reverse is the case; there are also frequently a few granules formed of the starch about the hilum but not so frequently as in *N. crispa*. A resistant marginal band is formed about the entire margin in most of the grains and this is sometimes invaded by cracks from the margin as in *N. crispa*, but usually is homogeneous in appearance as in *N. elegans*. The gelatinized grains are large, thin-walled, and as distorted as in *N. elegans*. *N. dainty maid* shows, qualitatively, a closer relationship to *N. elegans* than to *N. crispa*.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 80 per cent of the entire number of grains and 95 per cent of the total starch in 1 minute; in about 95 per cent of the grains and 99 per cent of the total starch in 3 minutes; in about 98 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 194.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 78 per cent of the entire number of grains and 95 per cent of the total starch in 5 minutes; in about 95 per cent of the grains and 98 per cent of the total starch in 15 minutes. (Chart D 195.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 88 per cent of the entire number of grains and 95 per cent of the total starch in 1 minute; in about 94 per cent of the grains and 97 per cent of the total starch in 3 minutes; in about 95 per cent of the grains and 99 per cent of the total starch in 5 minutes. (Chart D 196.)

The reaction with *potassium iodide* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 1 per cent of the grains and 3 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 9 per cent of the total starch in 30 minutes; in about 1 per cent of the grains and 12 per cent of the total starch in 45 minutes; in about 2 per cent of the grains and 15 per cent of the total starch in 60 minutes. (Chart D 197.)

The hilum and lamellæ are as distinct as in *N. crispa*, and gelatinization, as in the parents, begins at the hilum. The process of gelatinization in most of the grains is somewhat closer to that described under *N. elegans*, but in a moderate number it is closer to that described under *N. crispa*. The gelatinized grains also are usually as distorted as in *N. elegans*, but some are the same as in *N. crispa*. In this reaction *N. dainty maid* shows qualitatively a somewhat closer relationship to *N. elegans* than to *N. crispa*.

The reaction with *potassium sulphocyanate* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 14 per cent of the grains and 42 per cent of the total starch in 15 minutes; in about 25 per cent of the grains and 70 per cent of the total starch in 30 minutes; in about 50 per cent of the grains and 85 per cent of the total starch in 45 minutes; in about 60 per cent of the grains and 90 per cent of the total starch in 60 minutes. (Chart D 198.)

The hilum and lamellæ are as distinct as in *N. crispa*. Gelatinization begins at the hilum as in the parents, and in most of the grains the reaction is the same as that described under *N. elegans*, except that the starch between the two initial fissures from the hilum becomes more refractive and is somewhat less resistant than in *N. elegans*, in this showing some relationship to *N. crispa*. In a few grains the reaction is the same as that described under *N. crispa*. The gelatinized grains are moderately large and are as distorted as in the parents. In this reaction *N. dainty maid* shows, qualitatively, a closer relationship to *N. elegans* than to *N. crispa*.

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 30 per cent of the entire number of grains and 63 per cent of the total starch in 5 minutes; in about 68 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 69 per cent of the grains and 91 per cent of the total starch in 30 minutes; in about 70 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 72 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 199.)

The hilum and lamellæ are as distinct as in *N. elegans*. Gelatinization begins at the hilum as in both parents, and in the majority of the grains the process is the same as that described under *N. elegans*, except that there is somewhat more fissuration and granule formation than in those grains. In a moderate minority of the grains the process is the same as that described under *N. crispa*. There are rather fewer grains in which the cap-

sule is dissolved than in *N. crispa,* probably the same number as in *N. elegans.* The gelatinized grains are usually large and thin-walled and as distorted as in *N. elegans.* In this reaction *N. dainty maid* shows qualitatively a somewhat closer relationship to *N. elegans* than to *N. crispa.*

The reaction with *sodium hydroxide* begins in a few grains in half a minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 1 per cent of the grains and 4 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 7 per cent of the total starch in 30 minutes; in about 12 per cent of the grains and 16 per cent of the total starch in 45 minutes; in about 14 per cent of the grains and 18 per cent of the total starch in 60 minutes. (Chart D 200.)

The reaction with *sodium sulphide* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about the same percentage of the grains and 3 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 5 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 6 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 7 per cent of the total starch in 60 minutes. (Chart D 201.)

The reaction with *sodium salicylate* begins in half a minute. Complete gelatinization occurs in about 67 per cent of the entire number of grains and 75 per cent of the total starch in 5 minutes; in about 96 per cent of the grains and 98 per cent of the total starch in 10 minutes. (Chart D 202.) The hilum, as in the parents, is distinct, and there is sometimes a bubble formed there, but not so often as in *N. crispa.* The lamellæ are not so distinct as in *N. crispa,* but the same as in *N. elegans.* A narrow refractive band, which is as refractive as in *N. elegans,* is quickly formed about the margins of the grains. Gelatinization as in *N. elegans* nearly always begins at the proximal end—and in a few grains first at the proximal end and then quickly at the distal end as in *N. crispa.* Gelatinization progresses as in *N. elegans;* the most resistant portion of the grain is near the distal end as in those grains, and invagination of the capsule at the proximal and distal ends during the final stage of the reaction is not so great as in *N. crispa.* The gelatinized grains are large and not so much distorted as in *N. crispa,* but the same as in *N. elegans.* In this reaction *N. dainty maid* shows qualitatively a closer relationship to *N. elegans* than to *N. crispa.*

The reaction with *calcium nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about the same percentage of the grains and 4 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 6 per cent of the total starch in 30 minutes; in about 3 per cent of the grains and 10 per cent of the total starch in 45 minutes; in about 4 per cent of the grains and 15 per cent of the total starch in 60 minutes. (Chart D 203.)

The reaction with *uranium nitrate* begins in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 8 per cent of the total starch in 15 minutes; in about 12 per cent of the grains and 20 per cent of the total starch in 30 minutes; in about 16 per cent of the grains and 30 per cent of the total starch in 45 minutes; in about 18 per cent of the grains and 38 per cent of the total starch in 60 minutes. (Chart D 204.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 13 per cent of the entire number of grains and 63 per cent of the total starch in 5 minutes; in about 70 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 83 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 88 per cent of the grains and 98 per cent of the total starch in 45 minutes; in about 97 per cent of the grains and in more than 99 per cent of the total starch in 60 minutes. (Chart D 205.)

The reaction with *cobalt nitrate* begins in a few grains in half a minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 0.5 per cent of the grains and slight advance in the total starch in 15 minutes; slight advance in 30 minutes; in the same percentage of the grains and 3 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 206.)

The reaction with *copper nitrate* begins in a few grains in 2 minutes. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about the same percentage of the grains and 5 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 20 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 25 per cent of the total starch in 45 minutes; in about 8 per cent of the grains and 33 per cent of the total starch in 60 minutes. (Chart D 207.)

The reaction with *cupric chloride* begins in a few grains in half a minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 0.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; very little advance in 30 minutes; in about the same percentage of the grains and 3 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 208.)

The reaction with *barium chloride* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; little if any further change in 30, 45, and 60 minutes, respectively. (Chart D 209.)

The reaction with *mercuric chloride* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in less than 0.5 per cent of the grains and 2 per cent of the total starch in 30 minutes; slight progress in 45 minutes; in about 0.5 per cent of the grains and 3 per cent of the total starch in 60 minutes. (Chart D 210.)

Nerine Queen of Roses (Hybrid).

(Plate 6, fig. 36; Charts D 190 to D 210.)

Histologic Properties.

In *form* the grains are usually simple and isolated, but there are more aggregates containing more component grains, and more compound grains, than in either parent or in *N. dainty maid.* The compound grains are of the character described under *N. elegans.* The grains are less regular than those of *N. elegans,* but more regular than those of *N. crispa* and *N. dainty maid.* The causes of any irregularities are the same as in *N. elegans,* except that notches in the distal margin are not so common as in that starch. The conspicuous forms are ovoid and elliptical with flattened distal end, even among the small grains, in which respect it resembles *N. elegans;* however, there are more small, round grains than in that starch. There are also pyriform, triangular with rounded angles, and a few of the spatulate forms seen in *N. crispa.*

The grains of this hybrid are more like *N. elegans* than *N. crispa* in form. This hybrid differs from *N. dainty maid,* in a greater resemblance to *N. crispa* in being more regular in form, and in having more aggregates and compound grains.

The *hilum* is as distinct as in *N. crispa* and *N. dainty maid,* but is very rarely fissured, and in the latter respect is more like *N. elegans* and *N. dainty maid.* The hilum is eccentric from 0.36 to 0.17, usually 0.21 of the longitudinal axis, more than in either parent. The character and the eccentricity of the hilum are, on the whole, more like *N. elegans* than *N. crispa.*

N. queen of roses and *N. dainty maid* more closely resemble one another in the character of the hilum than either resembles either parent, but both are nearer *N. elegans* than *N. crispa.*

The *lamellæ* are about as fine and as distinct and are of the same character and arrangement as in *N. crispa;* the number counted on the larger grains varies from 16 to 30, usually 24; in character and arrangement they are closer to *N. crispa* than to *N. elegans,* but in number closer to *N. elegans.* The lamellæ of *N. queen of roses* are nearer, on the whole, to *N. crispa* than are those of *N. dainty maid,* and the latter are nearer to *N. elegans* than to *N. crispa.*

The *size* of the grains varies from 3 by 3μ for the smaller to 44 by 28μ in length and breadth for the larger. The common size is 22 by 16μ. In size *N. queen of roses* is smaller than either parent, but nearer *N. elegans* than *N. crispa. N. queen of roses* is smaller than *N. dainty maid,* but slightly closer to *N. dainty maid* than the latter is to either parent, but not so close to *N. elegans* as is *N. dainty maid.*

Polariscopic Properties.

The *figure* is slightly to very eccentric, usually eccentric, distinct, and clear-cut as in *N. elegans.* The lines are commonly finer than in *N. elegans* but intersect obliquely, and are bent and bisected as in *N. elegans.*

The *degree of polarization* is moderate to very high (value 77), less than in either parent or in *N. dainty maid,* and there are more of the moderately high than in either parent or in *N. dainty maid.*

With *selenite* the quadrants are usually well defined, and often somewhat more irregular in shape than in *N. elegans* and always unequal in size. The colors are less often pure than in *N. elegans,* and the yellow is less often pure than the blue. A very few of the grains have a greenish tinge.

In degree of polarization, character of the figure, and appearances with selenite *N. queen of roses* is closer to *N. elegans* than to *N. crispa,* and closer to *N. elegans* in all polariscopic characteristics than in *N. dainty maid.*

Iodine Reactions.

With 0.25 Lugol's solution the grains color a moderate blue with a tinge of violet (value 55), the same as in *N. elegans,* but deeper than in *N. crispa* and not so deep as in *N. dainty maid,* and the color rapidly deepens to very deep as in *N. elegans.* With 0.125 per cent Lugol's solution, the grains color a moderate to light blue with a tinge of violet, the same as in *N. elegans* and the color deepens, as in those grains, to a moderately deep to deep. After heating in water until the grains are gelatinized, and then adding 2 per cent Lugol's solution, the *grains* color a moderately deep to very deep indigo-blue, as in *N. crispa;* the *capsules* usually can not be distinguished, but when they can they color a purer violet as in *N. crispa;* the *solution* colors a moderately deep indigo-blue as in *N. crispa.* If the preparation is boiled for 2 minutes, and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* color light to deep indigo-blue, as in *N. crispa,* the *capsules* (not all of which can be distinguished) a pure violet as in *N. crispa,* and the *solution* a deep indigo-blue.

Quantitatively and qualitatively the iodine reactions of the unheated grains of *N. queen of roses* are closer to *N. elegans,* and qualitatively the reaction of the gelatinized grains are closer to *N. crispa.*

The iodine reactions of the unheated grains of *N. queen of roses* are closer to *N. elegans* than are those of *N. dainty maid;* and those of the gelatinized grains more closely resemble *N. crispa,* while those of *N. dainty maid* resemble *N. elegans.*

Aniline Reactions.

With *gentian violet* the grains color very lightly at once, and in half an hour they are light to moderately colored (value 40), the same as in *N. crispa.* As in the parents there is inequality of coloring between different grains and in individual grains.

With *safranin* the grains color very lightly at once, and in half an hour they are moderately colored (value 50), the same as in *N. crispa.* As in the parents there is inequality of coloring between different grains and in individual grains.

In the reactions to aniline stains, *N. queen of roses* shows a closer relationship to *N. crispa* than to *N. elegans;* it is closer to *N. crispa* than to *N. dainty maid,* which in turn is closer to *N. elegans.*

Temperature Reactions.

The majority of the grains are gelatinized at 68° to 69.1° C., and all at 71° to 72.8° C., mean 71.9° C., or 1.2° higher than in *N. crispa,* 4° lower than in *N. elegans,* and 1.3° C. lower than in *N. dainty maid.*

The temperature of gelatinization of *N. queen of roses* is intermediate between the parents and closer to *N. crispa* than to *N. elegans,* and it is closer to *N. crispa* than is that of *N. dainty maid.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 60 per cent of the entire number of grains and 70 per cent of the total starch in 5 minutes; in about 98 per cent of the grains and 99 per cent of the total starch in 15 minutes. (Chart D 190.)

The hilum is as distinct as in the parents, and there are very few bubbles formed there as in *N. elegans* and *N. dainty maid.* The lamellæ are as distinct as in *N. elegans,* and less distinct than in *N. crispa.* A broad refractive band, more refractive and distinct than in *N. crispa* but the same as in *N. elegans,* is quickly formed about the margins of the grains. Gelatinization as in *N. crispa* begins, usually, first at the distal end and then at the proximal, or less often at the distal end alone, and, very seldom at the proximal end first and then at the distal. Gelatinization progresses in most of the grains as in *N. crispa* and in a moderate number as in *N. elegans.* Most of the gelatinized grains are large and very much distorted as in *N. crispa,* but some are less distorted as in *N. elegans.*

In this reaction *N. queen of roses* shows qualitatively a somewhat closer relationship to *N. crispa* than to *N. elegans,* and not so close to *N. crispa* as is *N. dainty maid* to *N. elegans,* and there is nearly as much difference between the hybrids themselves as there is between *N. queen of roses* and *N. elegans.*

The reaction with *chromic acid* begins in rare grains immediately. Complete gelatinization occurs in much less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; still in less than 0.5 per cent of the grains and 4 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 34 per cent of the total starch in 30 minutes; in about 66 per cent of the grains and 86 per cent of the total starch in 45 minutes; in more than 95 per cent of the grains and total starch in 60 minutes. (Chart D 191.)

The reaction with *pyrogallic acid* begins in rare grains immediately. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; very slight advance in 15 and 30 minutes; still in less than 0.5 per cent of the grains and total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 192.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 21 per cent of the entire number of grains and 75 per cent of the total starch in 5 minutes; in about 65 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 86 per cent of the grains and 98 per cent of the total starch in 30 minutes; in about 93 per cent of the grains and in more than 99 per cent of the total starch in 45 minutes. (Chart D 193.)

The hilum and lamellæ are as distinct as in *N. elegans.* Gelatinization, as in the parents, begins at the hilum, and usually the proximal end (as in *N. elegans* and *N. dainty maid*) is less resistant than the distal end; but in more grains than in *N. dainty maid,* the distal end as in *N. crispa* is less resistant than the proximal end; and as a rule, granules are more frequently formed from the starch about the hilum than in *N. dainty maid,* but less frequently than in *N. crispa.*

The gelatinized grains are large and thin-walled and most of them are as distorted as in *N. elegans,* but a moderate number are as distorted as in *N. crispa.*

In this reaction *N. queen of roses* shows qualitatively a somewhat closer relationship to *N. elegans* than to *N. crispa,* but is not so close to *N. elegans* as is *N. dainty maid,* while the two hybrids are close to one another.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 94 per cent of the entire number of grains and in more than 99 per cent of the entire number of grains and in more than 99 per cent of the total starch in 1 minute; in 100 per cent of the grains and total starch in 3 minutes. (Chart D 194.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 79 per cent of the entire number of grains and 98 per cent of the total starch in 5 minutes; in about 97 per cent of the grains and in more than 99 per cent of the total starch in 15 minutes. (Chart D 195.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 97 per cent of the entire number of grains and in more than 99 per cent of the total starch in 1 minute; in more than 99 per cent of the grains and total starch in 3 minutes; about the same in 5 minutes. (Chart D 196.)

The reaction with *potassium iodide* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 3 per cent of the total starch in 15 minutes; in about 0.5 per cent of the grains and 6 per cent of the total starch in 30 minutes; in about 1 per cent of the grains and 11 per cent of the total starch in 45 minutes; in about 2 per cent of the grains and 19 per cent of the total starch in 60 minutes. (Chart D 197.) The hilum and lamellæ are as distinct as in *N. crispa.* Gelatinization begins at the hilum as in the parents, and the progress in the majority of the grains is the same as that described under *N. elegans,* while in a smaller number than in *N. dainty maid* it is the same as in *N. crispa.* The gelatinized grains are, as a rule, as distorted as in *N. elegans.* In this reaction *N. queen of roses* shows, qualitatively, a somewhat closer relationship to *N. elegans* than to *N. crispa;* but does not show so close a relationship to *N. elegans* as does *N. dainty maid,* while the 2 hybrids show a very close relationship to one another.

The reaction with *potassium sulphocyanate* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 14 per cent of the grains and 36 per cent of the total starch in 15 minutes; in about 20 per cent of the grains and 65 per cent of the total starch in 30 minutes; in about 40 per cent of the grains and 80 per cent of the total starch in 45 minutes; in about 60 per cent of the grains and 88 per cent of the total starch in 60 minutes. (Chart D 198.) The hilum and lamellæ are not so distinct as in *N. crispa,* but somewhat more distinct than in *N. elegans.* Gelatinization begins at the hilum as in the parents, and in a small majority of the grains it is the same as in *N. elegans,* though in a moderate number it is the same as in *N. crispa.* The gelatinized grains are moder-

ately large and as distorted as in the parents. In this reaction *N. queen of roses* shows qualitatively a somewhat closer relationship to *N. elegans* than to *N. crispa*, but is not so close to *N. elegans* as is *N. dainty maid*, and the two hybrids are very close to one another.

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 45 per cent of the entire number of grains and 75 per cent of the total starch in 5 minutes; in about 70 per cent of the grains and 92 per cent of the total starch in 15 minutes; in about 81 per cent of the grains and 94 per cent of the total starch in 30 minutes; in about 83 per cent of the grains and 96 per cent of the total starch in 45 minutes; in about 87 per cent of the grains and 99 per cent of the total starch in 60 minutes. (Chart D 199.)

The hilum and lamellæ are more distinct than in *N. elegans* and *N. dainty maid*, and the same as in *N. crispa*. Gelatinization, as in the parents, begins at the hilum. In a rather smaller majority of the grains than in *N. dainty maid*, the reaction is the same as in *N. elegans*, except that there is more fissuration and granulation as in *N. dainty maid*, and in a rather large minority it is the same as in *N. crispa*, except that there is not so much fissuration and granulation as in those grains. There are about the same number of grains as in *N. crispa* in which there is dissolution of the capsule at one point before gelatinization has progressed very far.

The gelatinized grains are large and thin-walled, and somewhat more distorted than in *N. elegans*, but, usually, somewhat less than in *N. crispa*.

In this reaction *N. queen of roses* shows, qualitatively, a somewhat closer relationship to *N. elegans* than to *N. crispa*, but not so close to *N. elegans* as is *N. dainty maid*. The two hybrids are very close to one another.

The reaction with *sodium hydroxide* begins in a few grains in half a minute. Complete gelatinization occurs in about 1 per cent of the grains and 3 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 8 per cent of the grain sand 12 per cent of the total starch in 30 minutes; in about 13 per cent of the grains and 15 per cent of the total starch in 45 minutes; in about 18 per cent of the grains and 22 per cent of the total starch in 60 minutes. (Chart D 200.)

The reaction with *sodium sulphide* begins in a few grains immediately. Complete gelatinization occurs in 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about the same percentage of the grains and 2 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 3 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 4 per cent of the total starch in 45 minutes; in about 2 per cent of the grains and 6 per cent of the total starch in 60 minutes. (Chart D 201.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 82 per cent of the entire number of grains and 93 per cent of the total starch in 3 minutes; in about 99 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 202.)

The hilum, as in the parents, is distinct and bubbles are as frequently formed there as in *N. dainty maid*, less than in *N. crispa*. The lamellæ are as distinct as in *N. crispa* and more distinct than in *N. elegans* and *N. dainty maid*. A narrow refractive band which is of the same refractivity as in *N. crispa*, and less than in *N. elegans* and *N. dainty maid*, is quickly formed about the margins of the grains. Gelatinization as in *N. crispa*, usually begins, first, at the distal end and then quickly at the proximal end, or first at the proximal end and then quickly at the distal end; but in many grains it begins as in *N. elegans*, first at the proximal end and does not begin at the distal end until about half of the grain has been gelatinized. The progress of gelatinization is in a small majority of the grains as described under *N. crispa*, but in many others as in *N. elegans*. The gelatinized grains are as large and usually as distorted as those of *N. crispa*. In this reaction *N. queen of roses* shows, qualitatively, a somewhat closer relationship to *N. crispa* than to *N. elegans*; but not so near to *N. crispa* as *N. dainty maid* is to *N. elegans*, and there is nearly as much difference between the two hybrids as there is between *N. queen of roses* and *N. elegans*.

The reaction with *calcium nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about the same percentage of the grains and 4 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 7 per cent of the total starch in 30 minutes; slight advance in 45 minutes; in about 3 per cent of the grains and 9 per cent of the total starch in 60 minutes. (Chart D 203.)

The reaction with *uranium nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 6 per cent of the total starch in 15 minutes; in about 6 per cent of the grains and 11 per cent of the total starch in 30 minutes; in about 9 per cent of the grains and 20 per cent of the total starch in 45 minutes; in about 11 per cent of the grains and 33 per cent of the total starch in 60 minutes. (Chart D 204.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 44 per cent of the entire number of grains and 88 per cent of the total starch in 5 minutes; in about 86 per cent of the grains and 99 per cent of the total starch in 15 minutes; in about 97 per cent of the grains and 99 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes. (Chart D 205.)

The reaction with *cobalt nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 15 minutes; slight progress in 30 and 45 minutes; and in about the same percentage of the grains and 3 per cent of the total starch in 60 minutes. (Chart D 206.)

The reaction with *copper nitrate* begins in a few grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and

total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 5 per cent of the total starch in 30 minutes; in about 4 per cent of the grains and 10 per cent of the total starch in 45 minutes; in about 10 per cent of the grains and 17 per cent of the total starch in 60 minutes. (Chart D 207.)

The reaction with *cupric chloride* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; very little advance in 15, 30, 45, and 60 minutes, respectively. (Chart D 208.)

The reaction with *barium chloride* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; slight progress in 15 minutes; in less than 0.5 per cent of the grains and total starch in 30 minutes; little if any further advance in 45 and 60 minutes, respectively. (Chart D 209.)

The reaction with *mercuric chloride* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 0.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; little if any further advance occurs in 30, 45, and 60 minutes, respectively. (Chart D 210.)

11. Starches of Nerine bowdeni, N. sarniensis var. corusca major, N. giantess, and N. abundance.

Nerine bowdeni (Seed Parent).

(Plate 7, figs. 37 and 40; Charts D 211 to D 231.)

Histologic Properties.

In *form* the grains are usually simple and isolated, but there are many compound grains and a moderate number of aggregates. The compound grains are very varied in character; some consist of 2 equal-sized grains, each composed of 8 or 9 lamellæ surrounded by 4 or 5 secondary common lamellæ; others of a large simple grain to whose distal margin usually 1 or sometimes 2 or more very small grains have become adherent, and all in turn are surrounded by 4 to 6 or 8 common lamellæ; others of 2 equal-sized grains, 1 or both of which are in turn compound; and yet others which are a combination of aggregate and compound grains—that is to say consisting of 2 small grains surrounded by a large number of common lamellæ and so making a large compound grain, to the distal end of which a smaller simple grain is adherent, or compound grains such as were described above in which 1 or 2 small simple or compound grains, after adhering to the distal margin of a large simple grain, are inclosed with this grain in a number of lamellæ, to whose margin in turn a simple grain became adherent. The aggregates usually consist of 2 or more equal-sized grains, linearly arranged, but not necessarily adherent at both distal ends, or of 1, 2, or many small grains adherent to the margin and surface of a large grain. There is also the combination of aggregate and compound grains mentioned above. The grains are irregular, the irregularities due to the following causes: (1) Many depressions and notches in the margin; (2) the greater development of one part of the distal end or of one side than the other; (3) low, rounded protuberances from the margin at various points; (4) a deviation of the longitudinal axis, usually near the middle, with a consequent bending of the grain; (5) the addition of small grains to larger ones forming irregular compounds. The conspicuous forms are broad ovoid, elliptical, lenticular, large irregularly quadrilateral and polygonal, and clam-shell-shapes; and, among the smaller grains, ovoid and elliptical. There are also pyriform and triangular; and, among the smaller grains, round and nearly round. The large broad quadrilateral and polygonal, and the clam-shell-shaped grains are flattened, the rest of the grains are not.

The *hilum* is a very distinct round or lenticular spot, which is rarely fissured; if present the fissure is a small angled, unbranched line. The hilum is not infrequently centric but is, as a rule, eccentric from 0.46 to 0.17, usually 0.35, of the longitudinal axis.

The *lamellæ* are very distinct and often rather fine, although coarse lamellæ are common. The lamellæ about the hilum may be coarse and those about the distal end fine, or the reverse, or there may be many coarse lamellæ throughout the grain forming bands, or dividing the fine lamellæ into bands of varying width; or again, there may be only two or three coarse lamellæ separating broad bands of fine lamellæ. The number counted on the larger grains varies from 20 to 40, usually 32.

In *size* the grains vary from the smaller which are 8 by 8μ, and 10 by 6μ, to the larger broad forms which are 52 by 72μ, and 58 by 60μ, to the larger more elongated forms which are 66 by 40μ, and 66 by 34μ, in length and breadth. The common sizes are 40 by 24μ and 36 by 34μ.

Polariscopic Properties.

The *figure* is nearly centric to very eccentric, the mean being moderately eccentric, distinct, and moderately clear-cut. The lines are commonly not very fine and intersect obliquely at varying angles, but may not intersect at all but only approach one another at the hilum. They are often very much bent and sometimes bisected, and there may be 5 or 6 lines instead of 4.

The *degree of polarization* is moderate to very high (value 85). It varies in different grains, a few having a moderate, and more a very high polarization, the majority having a high polarization. Considerable variation in polarization in the same aspect of a given grain is often present.

With *selenite* the quadrants are usually moderately well defined, unequal in size, and irregular in shape. The colors are usually pure, but moderately often are not pure, the yellow less often pure than the blue. A moderate number of the grains have a greenish tinge.

Iodine Reactions.

With 0.25 per cent Lugol's solution, the grains color a moderate blue-violet (value 50), which very rapidly becomes deep to very deep, the bluish tint increasing. With 0.125 per cent Lugol's solution the grains color a light blue-violet which deepens rapidly, becoming more blue, the depth varying from moderately deep to deep. After heating in water until the grains are gelatinized, and then adding a 2 per cent Lugol's solution, the *grains* color a very light to very deep indigo-blue, the

mean being moderate in depth; the *capsules* which can sometimes be seen, color a pure violet, and the *solution* a deep indigo-blue. If the preparation is boiled for 2 minutes, and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* color a light to deep indigo-blue with a tinge of violet, the *capsules* a pinkish violet, and the *solution* a very deep indigo.

Aniline Reactions.

With *gentian violet* the grains begin to stain lightly at once, and in half an hour they are moderately stained (value 45). Some grains are stained more than others, and there is unevenness of coloring of parts of a few of the individual grains.

With *safranin* the grains begin to stain lightly at once, and in half an hour they are moderately stained (value 50), more than with gentian violet. Some of the grains are stained more than others, and there is unevenness of coloring of parts of a few of the individual grains.

Temperature Reactions.

The majority of the grains are gelatinized at 67.6° to 67.9° C., and all at 74° to 75° C., mean 74.5° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 23 per cent of the grains and 26 per cent of the total starch in 15 minutes; in about 37 per cent of the grains and 39 per cent of the total starch in 30 minutes; in about 49 per cent of the grains and 52 per cent of the total starch in 45 minutes; in about 53 per cent of the grains and 56 per cent of the total starch in 60 minutes. (Chart D 211.)

The hilum is distinct and a bubble is often formed there. The lamellæ slowly become very distinct. A broad and very refractive band is formed about the margins of the grains. Gelatinization begins at various points on the margin, usually either at the distal end or at the margin of the two ends of the transverse axis in the broad grains, and occasionally at the proximal first, then at the distal end. Gelatinization progresses smoothly as a rule, with some invasion by fissures and breaking off of fragments of the ungelatinized material, the margin being less resistant as a rule than the central portion of the grain. The most resistant part is, usually, first distal to the hilum, but is sometimes at the proximal or the distal margin, and when this part is reached its gelatinization is accompanied by considerable infolding of the capsule of the already gelatinized portion. The gelatinized grains are large and very much distorted, and retain but little resemblance to the form of the untreated grain.

The reaction with *chromic acid* begins in very rare grains in half a minute. Complete gelatinization occurs in much less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; still in less than 0.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 7 per cent of the grains and 75 per cent of the total starch in 30 minutes; in about 37 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 60 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 212.)

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization was not observed in any grains, and had begun in but few, about 0.5 per cent of the total starch being gelatinized in 5 minutes; very slight advance in 15 and 30 minutes; complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 45 minutes; little if any advance in 60 minutes. (Chart D 213.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 25 per cent of the entire number of grains and 58 per cent of the total starch in 5 minutes; in about 54 per cent of the grains and 80 per cent of the total starch in 15 minutes; in about 75 per cent of the grains and 92 per cent of the total starch in 30 minutes; in about 84 per cent of the grains and 96 per cent of the total starch in 45 minutes; in about 85 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 214.)

The hilum and lamellæ are both very distinct, and the lamellæ remain so during the greater part of the reaction, particularly at the proximal end. Gelatinization begins at the hilum, which enlarges somewhat and 2 refractive fissures extend distally in the slender forms and sideways in the broad forms, branching extensively as they near the margin so that the whole region included between them is converted into a mass of granules. The starch to either side of these fissures along their courses becomes gelatinous, while the whole grain enlarges somewhat and becomes more nearly transparent but retains its structure. Then the hilum begins to enlarge and the portion immediately surrounding it is divided into many rather coarse granules by irregular fissuring. The material between the 2 fissures before mentioned is now moderately rapidly gelatinized from the hilum outward, and the more resistant material at the proximal end forms a striated, lamellated, marginal band which does not by any means extend completely around the grain, this is invaded by deep cracks from the margin and divided into coarse regular granules, which are gelatinized from the margin inward; in the meantime accompanying the gelatinization of the rest of the grain and the enlargement of the hilum, the granules surrounding the hilum are scattered throughout the proximal end and these may remain for some time after the rest of the grain is gelatinized. Towards the end of the reaction the capsules of many grains are split in all manner of ways and the grain separated into various-sized pieces.

The gelatinized grains are large and very much distorted and do not retain any of the form of the untreated grain.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 65 per cent of the entire number of grains and 84 per cent of the total starch in 1 minute; in about 84 per cent of the grains and 97 per cent of the total starch in 3 minutes; in about 93 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 215.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 43 per cent of the entire number of grains and 76 per cent of the total starch in 5 minutes; in about 71 per cent of

the grains and 93 per cent of the total starch in 15 minutes; in about 76 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about the same percentage of the grains and in more than 99 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 216.) A small area of the margin in a number of grains is very resistant.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 86 per cent of the entire number of grains and 95 per cent of the total starch in 3 minutes; in about 90 per cent of the grains and 96 per cent of the total starch in 5 minutes; in about 94 per cent of the grains and 98 per cent of the total starch in 15 minutes. (Chart D 217.)

The reaction is rapid up to 15 minutes. Observation was made at 3 minutes for comparison with other set. The small percentage remaining after 15 minutes is very resistant, very little change up to 60 minutes.

The reaction with *potassium iodide* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 2 per cent of the grains and 9 per cent of the total starch in 15 minutes; in about 6 per cent of the grains and 25 per cent of the total starch in 30 minutes; in about 31 per cent of the grains and 47 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 218.)

The hilum is very distinct and a bubble is never formed there. The lamellæ, also, are more distinct than in any other of *Nerine* studied. Gelatinization begins at the hilum which enlarges slowly. First the starch immediately surrounding the hilum is divided by irregular radiating fissures into granules, and then 2 refractive fissures, which branch at the distal end, extend from the hilum to the distal margin. The portion of the grain included between these 2 fissures becomes more hyaline in appearance and then is divided into fine granules. As the hilum continues to enlarge the more resistant starch at the proximal end and sides forms a thick, refractive marginal band, which is invaded by a number of cracks from the margin and so divided into coarse granules. The granules about the hilum gelatinize first, then the fine granules between the hilum and the distal margin. In the meantime the coarse granules at the proximal margin become less distinctly separated from one another, as they grow smaller and more transparent and the marginal band of which they form a part becomes thinner, more hyaline and more homogeneous in appearance, until only the thin, nearly transparent capsule is left. The gelatinized grains are very large and considerably distorted and do not retain much resemblance to the form of the untreated grain.

The reaction with *potassium sulphocyanate* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 25 per cent of the grains and 46 per cent of the total starch in 15 minutes; in about 48 per cent of the grains and 78 per cent of the total starch in 30 minutes; in about 61 per cent of the grains and 83 per cent of the total starch in 45 minutes; in about 74 per cent of the grains and 90 per cent of the total starch in 60 minutes. (Chart D 219.)

The hilum is very distinct and a bubble is not formed there in any of the grains. The lamellæ are very distinct and remain so throughout the greater part of the reaction. Before gelatinization begins 2 fissures in the interior of the grain extend out on either side nearly to the distal margin, and the portion lying between them becomes thinner and more refractive in appearance. Gelatinization begins at the hilum which enlarges slowly, and the starch immediately surrounding the hilum is divided, by irregular fissuration, into coarse granules, then the fissures before mentioned branch extensively and divide the deposit at the distal end, lying between them, into many rather fine granules irregularly arranged; while the rest of the starch between the hilum and the distal end is divided by striæ into fine granules in rows corresponding to the arrangement of the lamellæ. This granular material is then gelatinized from the hilum distally, excepting the coarse granules immediately about the hilum, which often persist until the rest of the grain is gelatinized. In the meantime the more resistant material at the proximal end and sides forms a thick striated, but non-lamellated marginal band which gradually grows thinner and more nearly transparent until only the thin capsule is left. Then the granules, mentioned before as the last to be gelatinized and which after the swelling of the grain are arranged around the inner border of the proximal marginal band, are slowly gelatinized.

The gelatinized grains are large and considerably distorted, but retain some resemblance to the form of the untreated grain.

The reaction with *potassium sulphide* begins in a few grains immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 12 per cent of the total starch in 5 minutes; in about 22 per cent of the grains and 47 per cent of the total starch in 15 minutes; in about 40 per cent of the grains and 62 per cent of the total starch in 30 minutes; in about 43 per cent of the grains and 68 per cent of the total starch in 45 minutes; in about 47 per cent of the grains and 71 per cent of the total starch in 60 minutes. (Chart D 220.)

The hilum is very distinct, and the lamellæ also are very distinct and remain so at the proximal end during the greater part of the reaction. Gelatinization begins at the hilum which enlarges slowly, and at the same time 2 refractive fissures appear which branch extensively and extend from the hilum to the distal margin. As the hilum continues to enlarge, the starch immediately surrounding it is divided by irregular fissures into coarse granules, and the lamellæ between the two refractive fissures are formed into rows of fine granules following the lines of the lamellæ, while the proximal deposit forms a non-striated, lamellated marginal band which in many grains is divided into portions of varying size by the inversion of fissures already existing at the hilum, which extend nearly to the margin. Later these portions become striated and then divided into granules and, as the grain continues to enlarge, the coarse granules which were originally about the hilum are arranged more or less regularly just within this marginal band. Gelatiniza-

tion is complete first at the distal margin, then at the proximal margin, the marginal band gelatinizing from without to the inner portion. The coarse granules just within this are the last to be gelatinized, and in some grains they form nearly a complete ring at the proximal end of the gelatinized grain which persists for a long time. A few grains are divided in all directions by fissures and become a mass of granules which are gelatinized rather irregularly. In a moderate number of grains the capsules also are dissolved at several points before gelatinization has progressed far, and each grain is divided into from 4 to 9 parts by slits that run from a common center. There are also grains whose capsules are dissolved at several points and split into several parts which may not always be completely separated from one another.

The gelatinized grains are large and very nearly transparent, and very much distorted. They do not retain any resemblance to the form of the untreated grains.

The reaction with *sodium hydroxide* begins in a few grains in half a minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 7 per cent of the grains and 12 per cent of the total starch in 15 minutes; in about 15 per cent of the grains and 21 per cent of the total starch in 30 minutes; in about 18 per cent of the grains and 24 per cent of the total starch in 45 minutes; in about 21 per cent of the grains and 30 per cent of the total starch in 60 minutes. (Chart D 221.)

The reaction with *sodium sulphide* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 4 per cent of the total starch in 30 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 45 minutes; in about 4 per cent of the grains and 7 per cent of the total starch in 60 minutes. (Chart D 222.)

The reaction with *sodium salicylate* begins in 2 minutes. Complete gelatinization occurs in about 33 per cent of the entire number of grains and 63 per cent of the total starch in 5 minutes; in about 67 per cent of the grains and 78 per cent of the total starch in 10 minutes; in about 78 per cent of the grains and 89 per cent of the total starch in 15 minutes; in about 99 per cent of the grains and more than 99 per cent of the total starch in 30 minutes. (Chart D 223.)

The hilum becomes very distinct and occasionally a bubble is formed there. The lamellæ are very distinct also and remain so during the greater part of the reaction. A narrow but distinct refractive band is formed rather slowly about the margins of the grains. Gelatinization is preceded by a pitted appearanc of the surfaces of the grain, and begins at the distal margin or in the broad grains at either end of the transverse axis and sometimes also at the proximal end. Gelatinization proceeds by fissuration of the ungelatinized starch and breaking off of small particles. The margin is less resistant than the central portion of the grain. In this manner the hilum is reached and swells rapidly, the proximal deposit gelatinizing rapidly, if not already gelatinized, leaving only the part just distal to the hilum ungelatinized. This is quickly gelatinized also and there is at the same time considerable folding in and invagination of the capsule at the distal and proximal ends. The gelatinized grains are large and much distorted, and do not retain any resemblance to the form of the untreated grain.

The reaction with *calcium nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 9 per cent of the grains and 17 per cent of the total starch in 30 minutes; in about 12 per cent of the grains and 25 per cent of the total starch in 45 minutes; in about 15 per cent of the grains and 28 per cent of the total starch in 60 minutes. (Chart D 224.)

The reaction with *uranium nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 13 per cent of the total starch in 15 minutes; in about 10 per cent of the grains and 27 per cent of the total starch in 30 minutes; in about 16 per cent of the grains and 37 per cent of the total starch in 45 minutes; in about 22 per cent of the grains and 44 per cent of the total starch in 60 minutes. (Chart D 225.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 16 per cent of the total starch in 5 minutes; in about 45 per cent of the grains and 69 per cent of the total starch in 15 minutes; in about 66 per cent of the grains and 85 per cent of the total starch in 30 minutes; in about 69 per cent of the grains and 89 per cent of the total starch in 45 minutes; in about 72 per cent of the grains and 91 per cent of the total starch in 60 minutes. (Chart D 226.)

The reaction with *cobalt nitrate* begins in rare grains in 2 minutes. Complete gelatinization occurs in much less than 0.5 per cent of the entire number of grains and total starch in 5 minutes with very slight advance in 15 and 30 minutes; and in about 0.5 per cent of the grains and 1 per cent of the total starch in 45 minutes with little if any advance in 60 minutes. (Chart D 227.)

The reaction with *copper nitrate* begins in a few grains in 2 minutes. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 7 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 10 per cent of the total starch in 30 minutes; in about 6 per cent of the grains and 16 per cent of the total starch in 45 minutes; in about 9 per cent of the grains and 20 per cent of the total starch in 60 minutes. (Chart D 228.)

The reaction with *cupric chloride* begins in rare grains in 2 minutes. Complete gelatinization occurs in much less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and total starch in 15 minutes;

in about 0.5 per cent of the grains and 1 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 2 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 229.)

The reaction with *barium chloride* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and total starch in 15 minutes; little if any further progress in 30, 45, and 60 minutes, respectively. (Chart D 230.)

The reaction with *mercuric chloride* begins in rare grains in two minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; very slight progress in 15 and 30 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 231.)

Nerine sarniensis var. corusca major (Pollen Parent).

(Plates 7 and 8, figs. 38, 41, 43, and 46; Charts D 211 to D 231.)

Histologic Properties.

In *form* the grains are usually simple and isolated, and there is a much smaller number of both compound grains and aggregates than in *N. bowdeni*. The compound grains are of two types: One of 2 grains each, each consisting of from 3 to 6 lamellæ and both surrounded by 3 to 5 or 6 common lamellæ; the other of 1, 2, or 3 very small grains, each consisting of a hilum and 1 or 2 lamellæ, grouped (often at different levels) at the proximal end of a large grain consisting of 14 to 20 common lamellæ. The grains are much more regular in form than those of *N. bowdeni* and any irregularities which occur are due to the following causes: (1) To a greater development of one part of the distal margin or of one side than of the rest of the grain; (2) to rounded protuberances, usually from the proximal end or sides; (3) to a deviation of the longitudinal axis with a consequent bending of the grain in the center or near the distal end; (4) in a few grains a secondary set of lamellæ whose longitudinal axis is at an angle with the longitudinal axis of the primary set; (5) much less frequently than in *N. bowdeni* to notches and depressions in the margin at various points. The conspicuous forms are broad elliptical with or without a flattened distal end, ovoid, and nearly round; and among the small grains, round and nearly round, and elliptical. There are also clam-shell, pyriform, and irregularly quadrilateral forms. The grains are not flattened, except the broad forms which are not so much flattened as the same forms in *N. bowdeni*. The grains are not so irregular nor so varied in form as those of *N. bowdeni*.

The *hilum* is not so distinct as in *N. bowdeni* and is even less frequently fissured than in that starch, but when fissuring occurs the fissures have the following forms: (1) A single, straight, transverse line, or an irregularly stellate figure. The hilum is sometimes centric, but usually eccentric from 0.45 to 0.22, commonly 0.3, of the longitudinal axis. The hilum is more eccentric than that of the grains of *N. bowdeni*.

The *lamellæ* are not quite so distinct as in *N. bowdeni*, and as a rule there are not so many coarse lamellæ as in those grains. They are continuous near the hilum but soon assume the form, often somewhat modified, of the outline of the grain, and they are much more regular in form than in *N. bowdeni*. The arrangement of the lamellæ varies somewhat from that of *N. bowdeni*, as the fine lamellæ are usually near the hilum and the coarse lamellæ at the distal end or in the central portion of the grain; the reverse, however, is the case in a moderate number of grains. While in most grains one very coarse refractive lamella is usually placed at about two-thirds the distance from the hilum to the distal margin, some grains which have otherwise no coarse lamellæ have (in addition to this especially refractive one) one or two others which divide the fine lamellæ into bands of varying breadth. The number of lamellæ counted on the larger grains varies from 20 to 36, usually 28.

The lamellæ of these grains are not so distinct nor so irregular as those of *N. bowdeni*, nor is there so large a number of coarse lamellæ as in those grains, and the arrangement of fine and coarse lamellæ varies in the kinds of grains.

In *size* the grains vary from the smaller which are 10 by 5μ and 7 by 7μ, to the larger broad forms which are 46 by 40μ, rarely, 48 by 60μ, and the larger more elongated forms which are 46 by 36μ, rarely 46 by 30μ, in length and breadth. The common sizes are 32 by 30μ and 32 by 20μ. The grains are not so large as those of *N. bowdeni* and there are not such broad forms as in that starch.

Polariscopic Properties.

The *figure* is nearly centric to eccentric, usually somewhat more eccentric, more distinct, and more clear-cut than in *N. bowdeni*. The lines are rather coarse, not so fine as in *N. bowdeni*, and less bent and bisected, and usually intersect obliquely with less variation of the angle than in *N. bowdeni*. There are fewer grains having 5 and 6 arms to the figure than in *N. bowdeni*.

The *degree of polarization* is moderate to very high (value 90), higher than in *N. bowdeni*. It varies in different grains, a few having a moderate and the majority a high polarization, but many more having a very high polarization than in *N. bowdeni*. There is not so much variation in polarization in the same aspect of a given grain as in *N. bowdeni*.

With *selenite* the quadrants are well defined and almost invariably of unequal size, and there is less irregularity in size and shape than in *N. bowdeni*. The colors are more apt to be pure than in *N. bowdeni*, and a greater number of grains have a greenish tinge.

Iodine Reactions.

With 0.25 per cent Lugol's solution, the grains color a moderately deep blue tinged with violet (value 60), the color is deeper and less violet in tint than in *N. bowdeni*, and it deepens as rapidly as in *N. bowdeni*, until it is deep to very deep. With 0.125 per cent Lugol's solution, the grains color a light to moderate blue with a tinge of violet. The color is deeper than in *N. bowdeni* and less violet in tint, and it deepens rapidly until it is deep. After heating in water until the grains are gelatinized, and then adding a 2 per cent Lugol's solution, the *grains* color a moderate to very deep indigo-blue, deeper than in

N. bowdeni; the *capsules* can not be distinguished; and the *solution* colors a moderately deep indigo-blue, less than in *N. bowdeni.* If the preparation is boiled for 2 minutes, and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* color a light to very deep indigo-blue with a tinge of violet, the mean being deeper than in *N. bowdeni;* the *capsules* a pure violet, without the pinkish tinge seen in *N. bowdeni;* and the *solution* a very deep indigo, somewhat less than in *N. bowdeni.*

Aniline Reactions.

With *gentian violet* the grains begin to stain lightly at once, and in half an hour they are light to moderately stained (value 40), less than in *N. bowdeni.* Some grains are stained more than others and there is unevenness of staining of parts of some of the individual grains.

With *safranin* the grains begin to stain lightly at once, and in half an hour they are light to moderately stained (value 35), considerably less than in *N. bowdeni.*

Temperature Reactions.

The majority of the grains is gelatinized at 70° to 71° C., and all but very rare resistant grains at 78° to 78.8° C., mean 78.4° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 8 per cent of the entire number of grains and 20 per cent of the total starch in 5 minutes; in about 73 per cent of the grains and 80 per cent of the total starch in 15 minutes; in about 92 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 97 per cent of the grains and 98 per cent of the total starch in 45 minutes; in about 98 per cent of the grains and more than 99 per cent of the total starch in 60 minutes. (Chart D 211.)

The hilum is less distinct than in *N. bowdeni,* and a bubble is not often formed there. The lamellæ are indistinct at first, and later are never so distinct as in *N. bowdeni.* A broad refractive band, which is not so refractive as in *N. bowdeni,* is formed about the margin of the grains. Gelatinization begins with equal frequency at the proximal or the distal margin, and progresses without fissuring of the ungelatinized portion as in *N. bowdeni,* but with serial separation and gelatinization of the lamellæ. The most resistant portion of the grains is nearer the distal margin than in *N. bowdeni.* The gelatinized grains are large and not so much distorted as in *N. bowdeni.*

The reaction with *chromic acid* begins in rare grains in half a minute. Complete gelatinization occurs in much less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; still in less than 0.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 65 per cent of the total starch in 30 minutes; in about 20 per cent of the grains and 86 per cent of the total starch in 45 minutes; in about 66 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 212.)

The reaction with *pyrogallic acid* begins in rare grains immediately. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 3 per cent of the total starch in 15 minutes; little if any further advance in 30, 45, and 60 minutes, respectively. (Chart D 213.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 9 per cent of the grains and 43 per cent of the total starch in 5 minutes; in about 51 per cent of the grains and 78 per cent of the total starch in 15 minutes; in about 69 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 83 per cent of the grains and 93 per cent of the total starch in 45 minutes; in about 87 per cent of the grains and 95 per cent of the total starch in 60 minutes. (Chart D 214.)

The hilum and lamellæ are very distinct but not so distinct as in *N. bowdeni.* Gelatinization, as in *N. bowdeni,* begins at the hilum, which enlarges slightly, and 2 fissures appear, extending distally from the hilum. These fissures branch out somewhat as they near the margin and the portion on either side becomes more nearly transparent; but in grains differing from those of *N. bowdeni,* the proximal end is less resistant than the distal end and the hilum and the grain swell first in this direction, and the starch immediately surrounding the hilum is divided into rather fine granules, which are not so numerous and are finer than in *N. bowdeni.* After all of the proximal deposit but a narrow band at the border is gelatinized, the distal margin begins to gelatinize from the hilum downward until the whole grain is gelatinized with the exception of a narrow homogeneous looking marginal band. This grows progressively thinner and more nearly transparent until only the thin capsule is left. The gelatinized grains are large and thin-walled and not so much distorted as in *N. bowdeni.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 77 per cent of the entire number of grains and 92 per cent of the total starch in 1 minute; in about 91 per cent of the grains and 98 per cent of the total starch in 3 minutes; in about 96 per cent of the grains and 99 per cent of the total starch in 5 minutes. (Chart D 215.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 40 per cent of the entire number of grains and 77 per cent of the total starch in 5 minutes; in about 78 per cent of the grains and 93 per cent of the total starch in 15 minutes; in about 84 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 88 per cent of the grains and 96 per cent of the total starch in 45 minutes; in about 90 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 216.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 88 per cent of the entire number of grains and 95 per cent of the total starch in 3 minutes; in about 90 per cent of the grains and 97 per cent of the total starch in 5 minutes; in about 94 per cent of the grains and 98 per cent of the total starch in 15 minutes. (Chart D 217.)

The reaction with *potassium iodide* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; slight progress

in 15 minutes; in about 0.5 per cent of the grains and 3 per cent of the total starch in 30 minutes; in about 1 per cent of the grains and 4 per cent of the total starch in 45 minutes; in about 2 per cent of the grains and 7 per cent of the total starch in 60 minutes. (Chart D 218.)

The hilum and lamellæ are very distinct, but not so distinct as in *N. bowdeni*. Gelatinization, as in *N. bowdeni*, begins at the hilum which enlarges very slowly, and the material immediately surrounding the hilum is divided into fine granules by fine, regular, radiating fissures. As gelatinization progresses, the lamellæ from the hilum to the distal margin are serially divided into granules and then gelatinized, while the more resistant material at the proximal end and sides forms a lamellated, faintly striated marginal band which is later broken up into granules by fissures, and the granules in turn are separated into groups by fan-shaped fissures from within. The outer part of this marginal band grows thinner and more nearly transparent as gelatinization proceeds, leaving an inner row of granules which persist long after the rest of the grain is gelatinized; in some grains these also are finally gelatinized. The gelatinized grains are large but are not so much distorted as in *N. bowdeni*.

The reaction with *potassium sulphocyanate* begins in a few grains immediately. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 0.5 per cent of the grains and 7 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 19 per cent of the total starch in 30 minutes; in about 12 per cent of the grains and 29 per cent of the total starch in 45 minutes; in about 20 per cent of the grains and 50 per cent of the total starch in 60 minutes. (Chart D 219.)

The hilum is distinct, but not so distinct as in *N. bowdeni*, and the lamellæ also are not so distinct as in this species, but are distinct and remain so during the greater part of the reaction. Gelatinization begins at the hilum as in *N. bowdeni*, but is not preceded by the extension of 2 fissures in the interior of the grain from the hilum to the distal end as in *N. bowdeni*. Such fissures do appear, but not until late in the reaction and are not extensive and do not branch at all. The grain does not become fissured nor granular as in *N. bowdeni*, and gelatinization usually occurs first at the proximal end and then at the distal end rather than first at the distal end as in *N. bowdeni*. The gelatinized grains are large and somewhat distorted, but not so much as in *N. bowdeni*.

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 23 per cent of the entire number of grains and 52 per cent of the total starch in 5 minutes; in about 47 per cent of the grains and 67 per cent of the total starch in 15 minutes; in about 54 per cent of the grains and 72 per cent of the total starch in 30 minutes; in about 58 per cent of the grains and 77 per cent of the total starch in 45 minutes; in about 63 per cent of the grains and 79 per cent of the total starch in 60 minutes. (Chart D 220.)

The hilum and lamellæ are distinct, but less distinct than in *N. bowdeni*. Gelatinization as in *N. bowdeni* begins at the hilum and two methods of procedure are noted. In the first, which occurs in the greater number of grains, the hilum enlarges smoothly in the direction of the proximal end as the starch here is less resistant than that at the distal end, and a thin homogeneous-looking refractive band is formed at the proximal margin by the last two or three lamellæ which are more resistant than the rest. This gradually becomes thinner and more nearly transparent until only the capsule is left. In the meantime the distal starch becomes indistinctly granular, and at the same time its lamellar arrangement is gelatinized from the hilum outwards, forming at last a homogeneous-looking mass at the distal margin which is the last part of the grain to be gelatinized. In the second method which occurs in the more resistant grains, the starch at the hilum is split into granules as it begins to enlarge, and gelatinization often occurs first in the distal material as in *N. bowdeni*. In a few of the grains there is dissolution of the capsule at one point as in *N. bowdeni*, but this is of much less frequent occurrence than in *N. bowdeni*.

The gelatinized grains are large and thin-walled and are not nearly so much distorted as in *N. bowdeni*, and retain some resemblance to the form of the untreated grain.

The reaction with *sodium hydroxide* begins in a few grains in half a minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 8 per cent of the grains and 11 per cent of the total starch in 30 minutes; in about 11 per cent of the grains and 18 per cent of the total starch in 45 minutes; and in about 20 per cent of the total starch in 60 minutes. (Chart D 221.)

The reaction with *sodium sulphide* begins in a few grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 4 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 5 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 6 per cent of the total starch in 45 minutes; in about 3 per cent of the grains and 8 per cent of the total starch in 60 minutes. (Chart D 222.)

The reaction with *sodium salicylate* begins in half a minute. Complete gelatinization occurs in about 77 per cent of the entire number of grains and 88 per cent of the total starch in 5 minutes; in about 96 per cent of the grains and 99 per cent of the total starch in 10 minutes. (Chart D 223.)

The hilum becomes distinct, but not so distinct as in *N. bowdeni*, and a bubble is never observed to be formed there. The lamellæ are distinct, but not so distinct as in *N. bowdeni*, and a narrow refractive band which is more refractive than in *N. bowdeni* is slowly formed about the margins of the grains. Gelatinization, differing from *N. bowdeni*, usually begins at the proximal end, and in a few grains this is followed by gelatinization of the distal end, but usually gelatinization progresses from the proximal to the distal end, in the manner described in *N. bowdeni*, except that the margin

does not gelatinize more rapidly than the rest of the grain and that the most resistant portion of the grains instead of being just distal to the hilum is at the distal margin. There are, however, a few grains in which gelatinization begins at the distal end, as in *N. bowdeni*, and proceeds as described under *N. bowdeni.*

The gelatinized grains are large but are not so distorted as in *N. bowdeni,* and they retain some resemblance to the form of the untreated grain.

The reaction with *calcium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about the same percentage of the grains and 2 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 8 per cent of the total starch in 30 minutes; in about 3 per cent of the grains and 12 per cent of the total starch in 45 minutes; in about 6 per cent of the grains and 16 per cent of the total starch in 60 minutes. (Chart D 224.)

The reaction with *uranium nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about the same percentage of the grains and 4 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 6 per cent of the total starch in 30 minutes; in about 2 per cent of the grains and 12 per cent of the total starch in 45 minutes; in about 5 per cent of the grains and 18 per cent of the total starch in 60 minutes. (Chart D 225.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 20 per cent of the entire number of grains and 56 per cent of the total starch in 5 minutes; in about 60 per cent of the grains and 80 per cent of the total starch in 15 minutes; in about 80 per cent of the grains and 88 per cent of the total starch in 30 minutes; in about 84 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 95 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 226.)

The reaction with *cobalt nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in much less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; slight advance in 15 and 30 minutes; in less than 0.5 per cent of the grains and 1 per cent of the total starch in 45 minutes, little if any further advance in 60 minutes. (Chart D 227.)

The reaction with *copper nitrate* begins in a few grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 15 minutes; in about the same percentage of the grains and 3 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 5 per cent of the total starch in 45 minutes; in about 1 per cent of the grains and 6 per cent of the total starch in 60 minutes. (Chart D 228.)

The reaction with *cupric chloride* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; very slight advance in 30, 45, and 60 minutes, respectively. (Chart D 229.)

The reaction with *barium chloride* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 0.5 per cent of the total starch in 5 minutes; little if any further progress in 15, 30, 45, and 60 minutes, respectively. (Chart D 230.)

The reaction with *mercuric chloride* begins in a few grains in 2 minutes. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; little if any further advance in 15, 30, 45, and 60 minutes, respectively. (Chart D 231.)

Nerine giantess (Hybrid).

(Plate 7, fig. 39; Charts D 211 to D 231.)

Histologic Properties.

In *form* the grains are usually simple and isolated, and the number of compound grains and of aggregates is much less than in *N. bowdeni,* but slightly more than in *N. sarniensis* var. *corusca major,* and the compound grains are like both the types noted exclusively in *N. bowdeni* and those which are common to both parents. The grains are closer to *N. bowdeni* in irregularity than to *N. sarniensis* var. *corusca major,* and the irregularities are due to the same causes as noted in the grains of *N. bowdeni;* it is to be noted, however, that there are more grains in which the irregularity is due to a secondary set of lamellæ whose longitudinal axis is at an angle with that of the primary set. The conspicuous forms are elliptical, ovoid, triangular, plano-convex, and clam-shell-shaped; and among the smaller grains round, nearly round, and elliptical. There are also finger-like, spatulate, lenticular, and pyriform, and a few of the large irregularly quadrilateral and polygonal forms seen in *N. bowdeni.*

In form *N. giantess* is nearer to *N. bowdeni* than to *N. sarniensis* var. *corusca major.*

The *hilum* is as distinct as in *N. bowdeni,* and is very rarely fissured as in *N. sarniensis* var. *corusca major.* It is sometimes centric but usually eccentric from 0.42 to 0.22, commonly 0.3, of the longitudinal axis, the same as in *N. sarniensis* var. *corusca major.*

In the character and eccentricity of the hilum *N. giantess* is nearer to *N. sarniensis* var. *corusca major* than to *N. bowdeni.*

The *lamellæ* are as distinct as in *N. bowdeni,* but are not so irregular as in those grains, but more than in *N. sarniensis* var. *corusca major.* They are, as a rule, arranged as in *N. bowdeni.* The number counted on the larger grains varies from 14 to 30, usually 20, less than in either parent.

In the character and arrangement of the lamellæ *N. giantess* is closer to *N. bowdeni* than to *N. sarniensis* var. *corusca major.*

In *size* the grains vary from the smaller which are 10 by 8μ, and 12 by 12μ, to the larger elongated forms which are 46 by 28μ, and 42 by 30μ, and the larger broad forms which are 40 by 46μ and 36 by 34μ. The common sizes are 34 by 26μ and 20 by 32μ.

The grains are nearer in size to *N. sarniensis* var. *corusca major* than to *N. bowdeni.*

Polariscopic Properties.

The *figure* is nearly centric to very eccentric, somewhat more eccentric than in *N. bowdeni*, the same as in *N. sarniensis* var. *corusca major*, and is distinct and usually more clear-cut than in *N. bowdeni*. The lines are finer than in *N. bowdeni* and *N. sarniensis* var. *corusca major*, and intersect obliquely as in *N. bowdeni*. They are less apt to be bent and bisected than in *N. bowdeni*, but much more than in *N. sarniensis* var. *corusca major*. A number of grains is noted which have 5 or 6 lines in the figure, but not so many as in *N. bowdeni*.

The *degree of polarization* is moderately high to very high (value 80), less than in either parent but closer to *N. bowdeni*. There are moderately high grains and fewer very high grains than in *N. bowdeni*. There is comparatively little variation in polarization in the same aspect of a given grain, as in *N. sarniensis* var. *corusca major*.

With *selenite* the quadrants are usually well defined, unequal in size, and less irregular in shape than in *N. bowdeni*, but considerably more than in *N. sarniensis* var. *corusca major*. The colors are more apt to be pure than in *N. bowdeni*, nearly as pure as in *N. sarniensis* var. *corusca major*, but there are a fewer grains having a greenish tinge.

In the character of the figure, the degree of polarization, and the appearances with selenite *N. giantess* is closer to *N. bowdeni* than to *N. sarniensis* var. *corusca major*.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains color a moderate to deep blue-violet (value 60), the same as in *N. sarniensis* var. *corusca major* in depth, and as *N. bowdeni* in tint. With 0.125 per cent Lugol's solution the grains color a light to moderate blue-violet, somewhat deeper than in *N. bowdeni*, but less than in *N. sarniensis* var. *corusca major*. After heating in water until the grains are gelatinized, and then adding a 2 per cent Lugol's solution, the *grains* color a very light to a very deep indigo-blue, the mean deeper than in *N. bowdeni*, but less than in *N. sarniensis* var. *corusca major*; the capsules, of which some can be distinguished, color violet as in *N. bowdeni*; and the *solution* a deep indigo-blue, somewhat less than in *N. bowdeni*, but more than in *N. sarniensis* var. *corusca major*. If the preparation is boiled for 2 minutes, and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* color a light to deep indigo with a tinge of red, somewhat more than in *N. bowdeni*, but distinctly less than in *N. sarniensis* var. *corusca major*; the *capsules* color a pinkish violet as in *N. bowdeni*; and the *solution* a very deep indigo as in *N. bowdeni*.

Quantitatively and qualitatively the iodine reactions of the unheated grains are closer to *N. sarniensis* var. *corusca major* than to *N. bowdeni*, but quantitatively and qualitatively in the grains that have been heated they are closer to *N. bowdeni* than to *N. sarniensis* var. *corusca major*.

Aniline Reactions.

With *gentian violet*, the grains are stained, lightly at once, and in half an hour they are moderately stained (value 45), the same as in *N. bowdeni*, and more than in *N. sarniensis* var. *corusca major*.

With *safranin* the grains are stained, lightly at once, and in half an hour they are moderately stained (value 50), the same as in *N. bowdeni*, and much more than in *N. sarniensis* var. *corusca major*.

The aniline reactions of these grains show a much closer resemblance to *N. bowdeni* than to *N. sarniensis* var. *corusca major*.

Temperature Reactions.

The majority of the grains are gelatinized at 68.2° to 69.1° C., and all at 70.9° to 71° C., mean 70.95° C.

The temperature of gelatinization of *N. giantess* is less than either parent and is closer to *N. bowdeni* than to *N. sarniensis* var. *corusca major*.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 10 per cent of the entire number of grains and 17 per cent of the total starch in 5 minutes; in about 75 per cent of the grains and 80 per cent of the total starch in 15 minutes; in about 89 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 94 per cent of the grains and 97 per cent of the total starch in 45 minutes; in about 98 per cent of the grains and 99 per cent of the total starch in 60 minutes. (Chart D 211.)

The hilum is as distinct as in *N. sarniensis* var. *corusca major*, but the lamellæ are not as distinct as in either parent. A broad refractive band, which is as refractive as in *N. sarniensis* var. *corusca major*, is formed about the margins of the grains. Gelatinization usually begins at the proximal end, and less often at the distal end and progresses as in *N. bowdeni*, but with less fissuring.

The gelatinized grains are larger and more distorted than in *N. sarniensis* var. *corusca major*, but not so much as in *N. bowdeni*.

In this reaction *N. giantess* shows qualitatively a closer relationship to *N. bowdeni* than to *N. sarniensis* var. *corusca major*.

The reaction with *chromic acid* begins in rare grains in 1 minute. Complete gelatinization occurs in much less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; still in less than 0.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 14 per cent of the grains and 68 per cent of the total starch in 30 minutes; in about 60 per cent of the grains and 89 per cent of the total starch in 45 minutes; in about 89 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 212.)

The reaction with *pyrogallic acid* begins in rare grains immediately. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; very little if any further advance in 30, 45, and 60 minutes, respectively. (Chart D 213.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 33 per cent of the total starch in 5 minutes; in about 33 per cent of the grains and 74 per cent of the total starch in 15 minutes; in about 53 per cent of the grains and 88 per cent of the total

starch in 30 minutes; in about 65 per cent of the grains and 92 per cent of the total starch in 45 minutes; in about 75 per cent of the grains and 95 per cent of the total starch in 60 minutes. (Chart D 214.)

The hilum and lamellæ are as distinct as in *N. sarniensis* var. *corusca major*. Gelatinization begins at the hilum as in the parents, and the proximal end is less resistant than the distal end in most of the grains, the process in these grains following closely that in the grains of *N. sarniensis* var. *corusca major*, the only difference being that there are more granules formed than in those grains, but not so many as in *N. bowdeni*. In a few grains the process is closer to that in *N. bowdeni*, but even here there is not the extensive granulation noted in *N. bowdeni*.

The gelatinized grains are large, thin-walled, and usually as distorted as in *N. sarniensis* var. *corusca major*.

In the reaction with nitric acid *N. giantess* shows qualitatively, a closer relationship to *N. sarniensis* var. *corusca major* than to *N. bowdeni*.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 80 per cent of the entire number of grains and 92 per cent of the total starch in 1 minute; in about 90 per cent of the grains and 96 per cent of the total starch in 3 minutes; in about 95 per cent of the grains and 97 per cent of the total starch in 5 minutes. (Chart D 215.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 31 per cent of the entire number of grains and 77 per cent of the total starch in 5 minutes; in about 80 per cent of the grains and 92 per cent of the total starch in 15 minutes; in about 87 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 90 per cent of the grains and 96 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 216.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 83 per cent of the entire number of grains and 93 per cent of the total starch in 3 minutes; in about 89 per cent of the grains and 95 per cent of the total starch in 5 minutes; in about 90 per cent of the grains and 97 per cent of the total starch in 15 minutes. (Chart D 217.)

The reaction with *potassium iodide* begins in a few grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 9 per cent of the total starch in 15 minutes; in about 6 per cent of the grains and 16 per cent of the total starch in 30 minutes; in about 16 per cent of the grains and 27 per cent of the total starch in 45 minutes; in about 23 per cent of the grains and 33 per cent of the total starch in 60 minutes. (Chart D 218.)

The hilum and lamellæ are very distinct as in *N. sarniensis* var. *corusca major*. Gelatinization as in the parents begins at the hilum, and the progress of gelatinization is somewhat closer to that noted in *N. sarniensis* var. *corusca major*, although there are more granules found throughout the grain and they are not so fine, in this more nearly resembling *N. bowdeni*.

The gelatinized grains are large and more distorted than in *N. bowdeni*, but less than in *N. sarniensis* var. *corusca major*.

In this reaction *N. giantess* shows qualitatively a somewhat closer relationship to *N. sarniensis* var. *corusca major* than to *N. bowdeni*.

The reaction with *potassium sulphocyanate* begins in a few grains immediately. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 9 per cent of the total starch in 15 minutes; in about 14 per cent of the grains and 23 per cent of the total starch in 30 minutes; in about 23 per cent of the grains and 36 per cent of the total starch in 45 minutes; in about 29 per cent of the grains and 63 per cent of the total starch in 60 minutes. (Chart D 219.)

The hilum and the lamellæ are more distinct than in *N. sarniensis* var. *corusca major*, but less than in *N. bowdeni*. Gelatinization begins at the hilum, as in the parents. The progress of the reaction in most of the grains is somewhat nearer *N. sarniensis* var. *corusca major* than *N. bowdeni*, although in many of the grains the starch immediately surrounding the hilum, and between the hilum and the distal end, becomes granular as in *N. bowdeni*, though the granules are not so coarse nor so numerous as in that species. The gelatinized grains are large and somewhat more distorted than in *N. sarniensis* var. *corusca major*, but not nearly so much so as in *N. bowdeni*.

In the reaction with potassium sulphocyanate *N. giantess* shows qualitatively a somewhat closer relationship to *N. sarniensis* var. *corusca major* than to *N. bowdeni*.

The reaction with *potassium sulphide* begins in a few grains immediately. Complete gelatinization occurs in about 11 per cent of the entire number of grains and 43 per cent of the total starch in 5 minutes; in about 25 per cent of the grains and 61 per cent of the total starch in 15 minutes; in about 39 per cent of the grains and 70 per cent of the total starch in 30 minutes; in about 43 per cent of the grains and 73 per cent of the total starch in 45 minutes; in about 45 per cent of the grains and 77 per cent of the total starch in 60 minutes. (Chart D 220.)

The hilum and lamellæ are more distinct than in *N. sarniensis* var. *corusca major*, but less than in *N. bowdeni*. Gelatinization (as in the parents) begins at the hilum, and in the less resistant grains, which are the most numerous, the process is the same as in *N. sarniensis* var. *corusca major*, except for the fact that it is accompanied by more fissuration and granulation of the distal starch; in the more resistant grains, of which there is a moderate number, the reaction is the same as that described in *N. bowdeni*. There are more grains in which dissolution of the capsules occurs than in *N. sarniensis* var. *corusca major*, but considerably fewer than in *N. bowdeni*. The gelatinized grains are large and thin-walled and more distorted than in *N. sarniensis* var. *corusca major*, but less than in *N. bowdeni*.

In the reaction with potassium sulphide *N. giantess* shows qualitatively, a somewhat closer relationship to *N. sarniensis* var. *corusca major* than to *N. bowdeni*.

The reaction with *sodium hydroxide* begins in a few grains in half a minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 15 minutes; in about 7 per cent of the grains and 10 per cent of the total starch in 30 minutes; in about 10 per cent of the grains and 14 per cent of the total starch in 45 minutes; and about 16 per cent of the total starch in 60 minutes. (Chart D 221.)

The reaction with *sodium sulphide* begins in a few grains immediately. Complete gelatinization occurs in 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 3 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 4 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 6 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 222.)

The reaction with *sodium salicylate* begins in half a minute. Complete gelatinization occurs in about 76 per cent of the entire number of grains and 89 per cent of the total starch in 5 minutes; in about 98 per cent of the grains and 99 per cent of the total starch in 10 minutes. (Chart D 223.)

The hilum and lamellæ are as distinct as in *N. sarniensis* var. *corusca major,* but less distinct than in *N. bowdeni,* and a narrow refractive band which is as distinct as in *N. sarniensis* var. *corusca major* is slowly formed about the margins of the grains. Gelatinization usually begins at the distal end and then at the proximal, as in many grains of *N. bowdeni,* but it may begin at the proximal end first, then at the distal end, as noted in both parents, and gelatinization progresses more smoothly than in either parent with less fissuration. The most resistant part of the grain is, as in *N. bowdeni,* usually just distal to the hilum, but gelatinization of this is not accompanied by so much infolding and invagination of the capsule as in *N. bowdeni,* and in this is more like *N. sarniensis* var. *corusca major.* The gelatinized grains are large and not so distorted as in *N. bowdeni,* but more than in *N. sarniensis* var. *corusca major. N. giantess* shows qualitatively a somewhat closer relationship to *N. bowdeni* than to *N. sarniensis* var. *corusca major.*

The reaction with *calcium nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 6 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 10 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 15 per cent of the total starch in 60 minutes. (Chart D 224.)

The reaction with *uranium nitrate* begins in a few grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 3 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 9 per cent of the total starch in 30 minutes; in about 3 per cent of the grains and 14 per cent of the total starch in 45 minutes; in about 7 per cent of the grains and 20 per cent of the total starch in 60 minutes. (Chart D 225.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 24 per cent of the entire number of grains and 65 per cent of the total starch in 5 minutes; in about 66 per cent of the grains and 88 per cent of the total starch in 15 minutes; in about 82 per cent of the grains and 91 per cent of the total starch in 30 minutes; in about 89 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 93 per cent of the grains and 96 per cent of the total starch in 60 minutes. (Chart D 226.)

The reaction with *cobalt nitrate* begins in rare grains in 2 minutes. Complete gelatinization occurs in much less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and total starch in 15 minutes; in less than 0.5 per cent of the grains and 1 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes. (Chart D 227.)

The reaction with *copper nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 0.5 per cent of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 3 per cent of the total starch in 30 minutes; in about 4 per cent of the grains and 10 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 15 per cent of the total starch in 60 minutes. (Chart D 228.)

The reaction with *cupric chloride* begins in a few grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; little if any advance in 30 and 45 minutes; in about the same percentage of the grains and 2 per cent of the total starch in 60 minutes. (Chart D 229.)

The reaction with *mercuric chloride* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; little if any further progress in 15, 30, 45, and 60 minutes, respectively. (Chart D 230.)

The reaction with *mercuric chloride* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and total starch in 15 minutes; little if any advance in 30, 45, and 60 minutes, respectively. (Chart D 231.)

Nerine abundance (Hybrid).

(Plate 7, fig. 42; Charts D 211 to D 231.)

Histologic Properties.

In *form* the grains are usually simple and isolated as in *N. sarniensis* var. *corusca major,* and there is even a smaller number of compound grains and of aggregates than in that starch; but occasionally a compound grain is seen of some of the types described under *N. bowdeni,* but not found in *N. sarniensis* var. *corusca major.* The grains are less irregular than those of *N. bowdeni* and

N. giantess, but considerably more irregular than those of *N. sarniensis* var. *corusca major,* and the irregularities are due to the same causes as described under the parents. The conspicuous forms are narrow, elongated or broad elliptical with or without a flattened distal end, ovoid, clam-shell-shaped, triangular, and large irregularly quadrilateral; and, among the smaller grains, round or nearly round, elliptical, pyriform, and lenticular. These grains appear to be very nearly mid-intermediate between those of the parents, but they are slightly nearer those of *N. sarniensis* var. *corusca major.* They are in form closer to those of *N. sarniensis* var. *corusca major,* and not so near those of *N. bowdeni* as those of *N. giantess.* The grains of the two hybrids closely resemble one another.

The *hilum* is as distinct as in *N. bowdeni,* but less frequently fissured than in those grains; when fissuring occurs it is of the types noted under *N. sarniensis* var. *corusca major.* The hilum is sometimes centric, but is usually eccentric from 0.44 to 0.2, commonly 0.25, of the longitudinal axis, somewhat greater than in either parent. The hilum in character is slightly nearer to *N. bowdeni,* and in eccentricity to *N. sarniensis* var. *corusca major,* and nearer *N. bowdeni* than is *N. giantess.*

The *lamellæ* are not so distinct or so irregular as in *N. bowdeni* and *N. giantess,* but more distinct and slightly more irregular than in *N. sarniensis* var. *corusca major.* In arrangement they are more like those of the grains of *N. sarniensis* var. *corusca major.* The number counted on the larger grains varies from 16 to 24, usually 18—a notably less number than in either parent. In character and arrangement of the lamellæ, these grains are nearer *N. sarniensis* var. *corusca major* than *N. bowdeni,* and the grains of this hybrid differ from those of *N. giantess* which are nearer *N. bowdeni,* while these are nearer *N. sarniensis* var. *corusca major.*

The grains in *size* vary from the smaller ones which are 8 by 8μ and 10 by 8μ, to the larger elongated forms which are 56 by 44μ and 56 by 34μ, and the larger broad forms which are 42 by 52μ, in length and breadth. The common sizes are 36 by 20μ, 34 by 32μ, and 28 by 32μ. These grains are, on the whole, intermediate in size between those of the parents, but closer to *N. bowdeni* than *N. sarniensis* var. *corusca major,* and also closer than are those of *N. giantess.*

Polariscopic Properties.

The *figure* is nearly centric to very eccentric, more eccentric than in either parent, and as distinct and more clear-cut than in *N. bowdeni.* The lines are as fine as in *N. bowdeni,* but finer than in *N. sarniensis* var. *corusca major,* and they intersect obliquely with less variation of the angle than in *N. bowdeni,* but more than in *N. sarniensis* var. *corusca major.* They are also less apt to be bent or bisected than in either *N. bowdeni* or *N. giantess,* but more than in *N. sarniensis* var. *corusca major.*

The *degree of polarization* is moderately high to very high (value 80), less than in either parent and the same as in *N. giantess.* There is comparatively little variation in polarization in the same aspect of a given grain as in *N. sarniensis* var. *corusca major* and *N. giantess.*

With *selenite* the quadrants as in *N. giantess* are usually well defined, unequal in size, and less irregular in shape than in *N. bowdeni,* but considerably more than in *N. sarniensis* var. *corusca major.* The colors are not so pure as in *N. giantess,* but somewhat more pure than in *N. bowdeni.*

In the degree of polarization, the character of the figure, and the appearances with selenite *N. abundance,* is closer to *N. bowdeni* than to *N. sarniensis* var. *corusca major.* *N. abundance* is not so near *N. bowdeni* as is *N. giantess,* but both hybrids are very close to one another.

Iodine Reactions.

With 0.25 per cent Lugol's solution, the grains color a moderate blue-violet (value 50), the same as *N. bowdeni* in depth and in tint. With 0.125 per cent Lugol's solution, they color a light blue-violet, less than in *N. bowdeni,* which deepens rapidly, becoming more blue. After heating in water, until all the grains are gelatinized and then adding 2 per cent Lugol's solution, the *grains* color a very light to deep indigo-blue, lighter than in *N. bowdeni;* the capsules, which can frequently be seen, color a pure violet; and the *solution* a deep indigo-blue, more than in *N. bowdeni.* If the preparation is boiled for 2 minutes, and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* color a very light to deep indigo-blue with a tinge of red less than in *N. bowdeni,* the *capsules* a pinkish violet as in *N. bowdeni,* and the *solution* a very deep indigo as in *N. bowdeni.* Qualitatively and quantitatively the iodine reactions of *N. abundance* are closer to *N. bowdeni* than to *N. sarniensis* var. *corusca major.*

Quantitatively the iodine reactions of the unheated grains of *N. abundance* and *N. giantess* are as far apart as are the parents, but both quantitatively and qualitatively the gelatinized grains of the two hybrids are very close to one another and to *N. bowdeni.*

Aniline Reactions.

With *gentian violet* the grains stain, lightly at once, and in half an hour they are light to moderately stained (value 40), the same as *N. sarniensis* var. *corusca major.*

With *safranin* the grains stain lightly at once, and in half an hour they are moderately stained (value 45) less than *N. bowdeni,* but more than in *N. sarniensis* var. *corusca major.*

The aniline reactions of this starch show a closer relationship to *N. sarniensis* var. *corusca major.* These grains are less light than those of *N. giantess,* and therefore nearer *N. sarniensis* var. *corusca major* in this respect, while those of *N. giantess* are closer to *N. bowdeni.* They are closer to one another, however, than the parents are to one another.

Temperature Reactions.

The majority of the grains are gelatinized at 69° to 69.9° C., and all at 73.9° to 74.8° C., mean 74.3° C.

The temperature of gelatinization of *N. abundance* is much closer to *N. bowdeni* than to *N. sarniensis* var. *corusca major,* and is higher than that of *N. giantess* and is also nearer *N. bowdeni.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 24 per cent of the entire number of grains and 45 per cent of the total starch in 5 minutes; in about 75 per cent of the grains and 82 per cent of the total starch in 15 minutes; in

about 94 per cent of the grains and 97 per cent of the total starch in 30 minutes; in about 97 per cent of the grains and 98 per cent of the total starch in 45 minutes; in about 98 per cent of the grains and in more than 99 per cent of the total starch in 60 minutes. (Chart D 211.)

The hilum is as distinct as in *N. sarniensis* var. *corusca major*, and the lamellæ are more distinct than in *N. sarniensis* var. *corusca major*, but less so than in *N. bowdeni*. A broad refractive band, which is as refractive as those of the grains of *N. sarniensis* var. *corusca major*, is formed about the margins of the grains. Gelatinization begins usually first at the distal end and then at the proximal end, but nearly as frequently first at the proximal end, and then at the distal end. Gelatinization progresses smoothly as in *N. bowdeni*, but without so much fissuring as in those grains, yet more than in *N. giantess*. The gelatinized grains are large and rather more distorted than in *N. sarniensis* var. *corusca major*, but less than in *N. bowdeni*.

In this reaction *N. abundance* shows qualitatively a closer relationship to *N. bowdeni* than to *N. sarniensis* var. *corusca major*, and is closer to *N. bowdeni* than is *N. giantess*, and the two hybrids are very close to one another.

The reaction with *chromic acid* begins in rare grains in half a minute. Complete gelatinization occurs in much less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; still in less than 0.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 62 per cent of the total starch in 30 minutes; in about 32 per cent of the grains and 85 per cent of the total starch in 45 minutes; in about 70 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 212.)

The reaction with *pyrogallic acid* begins in rare grains immediately. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 3 per cent of the total starch in 15 minutes; little if any further change occurs in 30, 45, and 60 minutes, respectively. (Chart D 213.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 32 per cent of the total starch in 5 minutes; in about 40 per cent of the grains and 70 per cent of the total starch in 15 minutes; in about 42 per cent of the grains and 81 per cent of the total starch in 30 minutes; in about 57 per cent of the grains and 87 per cent of the total starch in 45 minutes; in about 58 per cent of the grains and 91 per cent of the total starch in 60 minutes. (Chart D 214.)

The hilum and lamellæ are as distinct as in *N. sarniensis* var. *corusca major*. Gelatinization, as in the parents, begins at the hilum, and in most of the grains the process is the same as in *N. bowdeni*, while in a moderate number it is the same as in *N. sarniensis* var. *corusca major*. It is always accompanied by more fissuration and granule formation than in *N. sarniensis* var. *corusca major*, and less than in *N. bowdeni*. The gelatinized grains are large and thin-walled, and most of them are more distorted than in *N. sarniensis* var. *corusca major*, but some are nearly as distorted as in *N. bowdeni*.

In this reaction *N. abundance* shows, qualitatively, a somewhat closer relationship to *N. bowdeni* than to *N. sarniensis* var. *corusca major*, but is not so close to *N. bowdeni* as is *N. giantess* to *N. sarniensis* var. *corusca major*; but the two hybrids are close to one another.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 64 per cent of the entire number of grains and 86 per cent of the total starch in 1 minute; in about 86 per cent of the grains and 97 per cent of the total starch in 3 minutes; in about 92 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 215.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 40 per cent of the entire number of grains and 75 per cent of the total starch in 5 minutes; in about 77 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 83 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 85 per cent of the grains and 96 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 216.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 75 per cent of the entire number of grains and 93 per cent of the total starch in 3 minutes; in about 81 per cent of the grains and 95 per cent of the total starch in 5 minutes; in about 84 per cent of the grains and 97 per cent of the total starch in 15 minutes. (Chart D 217.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about 0.5 per cent of the grains and 3 per cent of the total starch in 30 minutes; in about 1 per cent of the grains and 5 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 8 per cent of the total starch in 60 minutes. (Chart D 218.)

The hilum and lamellæ are more distinct than in *N. sarniensis* var. *corusca major* and *N. giantess*, and less than in *N. bowdeni*. Gelatinization begins at the hilum as in both parents, and the process in most of the grains is closer to that in *N. bowdeni* except that the granules formed are not so numerous nor so coarse; but in a large majority the process is the same as in *N. sarniensis* var. *corusca major*.

The gelatinized grains are large and usually more distorted than in *N. sarniensis* var. *corusca major*, but somewhat less than in *N. bowdeni*.

In this reaction *N. abundance* shows qualitatively a somewhat closer relationship to *N. bowdeni* than to *N. sarniensis* var. *corusca major*, and *N. abundance* and *N. giantess* show qualitatively a closer relationship to one another than either does to the parent it most nearly resembles.

The reaction with *potassium sulphocyanate* begins in a few grains immediately. Complete gelatinization occurs in 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 5 per cent of the total starch

in 15 minutes; in about 2 per cent of the grains and 7 per cent of the total starch in 30 minutes; in about 3 per cent of the grains and 8 per cent of the total starch in 45 minutes; in about 4 per cent of the grains and 18 per cent of the total starch in 60 minutes. (Chart D 219.) (Experiment repeated with same results.)

The hilum and lamellæ are more distinct than in *N. sarniensis* var. *corusca major*, but less distinct than in *N. bowdeni*. Gelatinization begins at the hilum as in the parents, and is preceded by the appearance of 2 fissures in the interior of the grain, as in *N. bowdeni*. The reaction in most of the grains is the same as that described in *N. bowdeni*, except that there is not so much granulation and fissuration as in those grains. In a few grains the reaction is the same as that in *N. sarniensis* var. *corusca major*, but is accompanied by considerable granulation which is not found in these grains. The gelatinized grains are much swollen and more distorted than in *N. sarniensis* var. *corusca major*, but somewhat less than in *N. bowdeni*.

In this reaction, *N. abundance* shows, qualitatively a closer relationship to *N. bowdeni* than to *N. sarniensis* var. *corusca major*, and is closer to *N. bowdeni* than is *N. giantess* to *N. sarniensis* var. *corusca major*. The two hybrids are, however, closer to one another than is either to the parent it the more closely resembles.

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 15 per cent of the entire number of grains and 39 per cent of the total starch in 5 minutes; in about 39 per cent of the grains and 60 per cent of the total starch in 15 minutes; in about 44 per cent of the grains and 66 per cent of the total starch in 30 minutes; in about 47 per cent of the grains and 70 per cent of the total starch in 45 minutes; in about 54 per cent of the grains and 74 per cent of the total starch in 60 minutes. (Chart D 220.)

The hilum and lamellæ are, as in *N. giantess*, more distinct than in *N. sarniensis* var. *corusca major* and less than *N. bowdeni*. Gelatinization, as in the parents, begins at the hilum, and in a small majority of the grains it is the same as that described under *N. bowdeni*, except that fissuration is not so extensive and the granules formed are not so coarse; while in a moderately large minority the process is the same as described under *N. sarniensis* var. *corusca major*, except that there is more granulation and fissuration than in these grains.

The gelatinized grains are large and thin-walled and usually more distorted than in *N. sarniensis* var. *corusca major*, but less than in *N. bowdeni*.

In this reaction *N. abundance* shows qualitatively a somewhat closer relationship to *N. bowdeni* than to *N. sarniensis* var. *corusca major*, and is not so close to *N. bowdeni* as is *N. giantess* to *N. sarniensis* var. *corusca major*; but the two hybrids are close to one another.

The reaction with *sodium hydroxide* begins in a few grains in half a minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 0.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 30 minutes; in about 6 per cent of the grains and 10 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 221.)

The reaction with *sodium sulphide* begins in a few grains in 1 minute. Complete gelatinization occurs in 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; slight advance in 30 minutes; in about the same percentage of the grains and 3 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 222.)

The reaction with *sodium salicylate* begins in 1 minute. Complete gelatinization occurs in about 60 per cent of the entire number of grains and 86 per cent of the total starch in 5 minutes; in about 98 per cent of the grains and 99 per cent of the total starch in 10 minutes. (Chart D 223.)

The hilum and lamellæ are as distinct as in *N. sarniensis* var. *corusca major*, and less distinct than in *N. bowdeni*, and a narrow refractive band, which is as distinct as in *N. sarniensis* var. *corusca major*, is slowly formed about the margins of the grains. Gelatinization as in *N. bowdeni* usually begins first at the distal end and then at the proximal end, or at the distal end only, but in a few grains it begins, as in some grains of both parents, first at the proximal and later at the distal end. The progress of gelatinization resembles that in *N. bowdeni* even more than does that in *N. giantess*. The ungelatinized portion of the grain is invaded by fissures and small particles are split off as in *N. bowdeni*, and the most resistant part of the grain is just distal to the hilum, but gelatinization of this is not accompanied by so much infolding and invagination of the capsule as in *N. bowdeni*. The gelatinized grains are large but are not so distorted as in *N. bowdeni*.

In this reaction *N. abundance* shows qualitatively a closer relationship to *N. bowdeni* than to *N. sarniensis* var. *corusca major*, and is closer than *N. giantess* to *N. bowdeni*.

The reaction with *calcium nitrate* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 4 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 5 per cent of the total starch in 60 minutes. (Chart D 224.)

The reaction with *uranium nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about the same percentage of the grains and 2 per cent of the total starch in 30 minutes; in about 2 per cent of the grains and 4 per cent of the total starch in 45 minutes; in about 3 per cent of the grains and 8 per cent of the total starch in 60 minutes. (Chart D 225.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 19 per cent of

the total starch in 5 minutes; in about 26 per cent of the grains and 78 per cent of the total starch in 15 minutes; in about 62 per cent of the grains and 86 per cent of the total starch in 30 minutes; in about 72 per cent of the grains and 89 per cent of the total starch in 45 minutes; in about 75 per cent of the grains and 93 per cent of the total starch in 60 minutes. (Chart D 226.)

The reaction with *cobalt nitrate* begins in rare grains in 2 minutes. Complete gelatinization occurs in much less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; still in less than 0.5 per cent of both the grains and total starch in 15 minutes; very little progress in 30 minutes; in less than 0.5 per cent of the grains and total starch in 45 minutes; little if any further progress in 60 minutes. (Chart D 227.)

The reaction with *copper nitrate* begins in a few grains in 2 minutes. Complete gelatinization occurs in much less than 0.5 per cent of the grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and total starch in 15 minutes; in about 0.5 per cent of the grains and 2 per cent of the total starch in 30 minutes; in about 1 per cent of the grains and 3 per cent of the total starch in 45 minutes; very little if any advance in 60 minutes. (Chart D 228.)

The reaction with *cupric chloride* begins in a few grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; little if any further advance in 30, 45, and 60 minutes, respectively. (Chart D 229.)

The reaction with *barium chloride* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; very slight progress in 15 minutes; in less than 0.5 per cent of the grains and total starch in 30 minutes; little if any further progress in 45 and 60 minutes. (Chart D 230.)

The reaction with *mercuric chloride* begins in rare grains in 2 minutes. Complete gelatinization occurs in much less than 0.5 per cent of the grains and total starch in 5 minutes; very slight progress in 15 minutes; in less than 0.5 per cent of the entire number of grains and total starch in 30 minutes; little if any further advance in 45 and 60 minutes. (Chart D 231.)

12. Starches of Nerine sarniensis, var. corusca major, N. curvifolia var. fothergilli major, and N. Glory of Sarnia.

Starch of *Nerine sarniensis* var. *corusca major* (seed parent) is described on pp. 498 to 501.

Nerine curvifolia var. fothergilli major (Pollen Parent).

(Plate 8, figs. 44 and 47; Charts D 232 to D 252.)

Histologic Properties.

In *form* the grains are usually simple and isolated, but compound grains and aggregates are more common and more varied in type than in *N. sarniensis* var. *corusca major.* The aggregates are usually doublets but may be 3 or 4 small grains linearly arranged, and occasionally there are aggregates composed of compound grains. The compound grains are of four types: (1) 2 equal-sized grains, each composed of 5 or 6 lamellæ inclosed by 2 to 4 or 5 common lamellæ; (2) 2, 3, or even 4 small grains at the same or at different levels on the proximal end of a large grain composed of 16 to 20 common secondary lamellæ; (3) 3 or 4 hila set in a long amorphous-looking central portion surrounded by 2 or 3 common lamellæ and forming a long grain whose surface is indented in several places, as if to indicate separation into distinct simple grains; (4) an occasional type such as is described under *N. bowdeni* in which a small grain has become attached to the margin of a large grain and the two have been inclosed by 2 or more common lamellæ. The grains are slightly less regular than in *N. sarniensis* var. *corusca major,* and any irregularities are due to the following causes: (1) Secondary sets of lamellæ whose longitudinal axes are at angles with the longitudinal axes of the primary sets; (2) rounded protuberances from various parts of the margin, usually the proximal end; (3) a greater development of one part of the distal end or of one side than the rest; (4) depressions and notches in the margin (these occur in only a few grains). The conspicuous forms are elliptical, triangular with curved base, and ovoid; and among the smaller grains, round and nearly round, and elliptical. There are also lenticular, pyriform, clam-shell-shaped, round, and nearly round among the larger grains.

The grains of *N. curvifolia* var. *fothergilli major* are more frequently compound, and of more varied types, they occur in aggregates more frequently, and they are less regular, and are somewhat more slender and pointed, than those of *N. sarniensis* var. *corusca major.*

The *hilum* is more distinct than in *N. sarniensis* var. *corusca major* and is rarely fissured as in those grains; when a fissure occurs, it is either a small, straight or angled, transverse or oblique line, or an irregularly stellate cavity. The hilum is sometimes centric but usually eccentric from 0.46 to 0.19, commonly 0.26, of the longitudinal axis. It is more distinct and more eccentric than in *N. sarniensis* var. *corusca major.*

The *lamellæ* are more distinct than in *N. sarniensis* var. *corusca major* and usually coarse near the hilum and fine throughout the rest of the grains to the distal margin, with the exception of 1 or 2 coarse refractive lamellæ which may be placed at about one-half to three-quarters of the distance from the hilum to the distal margin. The number of lamellæ counted on the larger grains varies from 18 to 30, usually 24. The lamellæ of these grains are more distinct and less numerous than those of *N. sarniensis* var. *corusca major,* and differ from them in that the coarse lamellæ are usually grouped near the hilum.

In *size* the grains vary from the smaller which are 6 by 6μ and 6 by 4μ, to the larger elongated forms which are 44 by 28μ, and the larger broad forms which are 40 by 34μ, rarely 22 by 40μ, in length and breadth. The common sizes are 29 by 18μ and 30 by 24μ. The grains are slightly smaller and more slender than those of *N. sarniensis* var. *corusca major.*

Polariscopic Properties.

The *figure* is nearly centric to very eccentric, more eccentric than in *N. sarniensis* var. *corusca major.* It is as distinct and slightly more clear-cut than in *N. sarniensis* var. *corusca major.* The lines are not so coarse and are somewhat more apt to be bent and bisected than

in *N. sarniensis* var. *corusca major,* and they intersect obliquely with the variation in the angle noted in those grains.

The *degree of polarization* varies from moderate to very high (value 87), somewhat less than in *N. sarniensis* var. *corusca major* as there are more grains having moderately high and fewer having very high polarization than in those grains.

With *selenite* the quadrants are more often well defined and vary somewhat more in size and shape than in *N. sarniensis* var. *corusca major.* The colors are somewhat more pure and there are fewer grains having a greenish tinge than in *N. sarniensis* var. *corusca major.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains color a moderately deep blue with a tinge of violet (value 65), more than in *N. sarniensis* var. *corusca major,* and the color deepens very rapidly until it becomes deep to very deep. With 0.125 per cent Lugol's solution the grains color a light to moderate blue with a tinge of violet, more than in *N. sarniensis* var. *corusca major,* and the color deepens rapidly until it is deep. After heating in water until the grains are gelatinized and then adding a 2 per cent Lugol's solution the *grains* color a moderate to very deep indigo-blue, more than in *N. sarniensis* var. *corusca major;* the *capsules* can not be distinguished; and the *solution* colors a deep indigo, less than in *N. sarniensis* var. *corusca major.* If the preparation is boiled for 2 minutes, and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* color a moderate to very deep indigo-blue with a tinge of violet, deeper than in *N. sarniensis* var. *corusca major;* the *capsules* of which fewer can be seen than in *N. sarniensis* var. *corusca major,* a pure violet; and the *solution* a very deep indigo as in *N. sarniensis* var. *corusca major.*

Aniline Reactions.

With *gentian violet* the grains stain lightly at once, and in half an hour they are moderately stained (value 45), more than *N. sarniensis* var. *corusca major.* Some grains are stained more than others and there is some unevenness of coloring of the individual grains.

With *safranin* the grains stain lightly at once, and in half an hour they are moderately stained (value 45), more than in *N. sarniensis* var. *corusca major.* Some grains are stained more than others and there is some unevenness of coloring of the individual grains.

Temperature Reactions.

The majority of the grains are gelatinized at 68.1° to 69° C., and all at 73.2° to 74.3° C., mean 73.8° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in a few grains immediately. Complete gelatinization occurs in about 13 per cent of the entire number of grains and 21 per cent of the total starch in 5 minutes; in about 84 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 97 per cent of the grains and 98 per cent of the total starch in 30 minutes. (Chart D 232.)

The hilum is as distinct as in *N. sarniensis* var. *corusca major,* and the lamellæ are at first indistinct but later as distinct as in *N. sarniensis* var. *corusca major.* A broad refractive band, which is not so refractive as in *N. sarniensis* var. *corusca major,* is formed about the margins of the grains. Gelatinization begins with about equal frequency at the proximal and then at the distal end, or first at the distal and then at the proximal end, and in a moderate number of grains at either one or the other end without immediate gelatinization of the opposite end. Gelatinization progresses less smoothly than in *N. sarniensis* var. *corusca major* and is accompanied by fissuring of the ungelatinized starch. The most resistant part of the grain is just distal to the hilum, differing from *N. sarniensis* var. *corusca major* in which it was nearer the distal margin, and this may be split into two pieces by a furrow from the hilum, or it may be gelatinized in one piece. The gelatinized grains are very large and considerably distorted and show less resemblance to the form of the untreated grain than in *N. sarniensis* var. *corusca major.*

The reaction with *chromic acid* begins in rare grains in 1 minute. Complete gelatinization occurs in much less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; still in less than 0.5 per cent of the grains and 3 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 36 per cent of the total starch in 30 minutes; in about 38 per cent of the grains and 85 per cent of the total starch in 45 minutes; in about 90 per cent of the grains and more than 97 per cent of the total starch in 60 minutes. (Chart D 232.)

The reaction with *pyrogallic acid* begins in rare grains immediately. Complete gelatinization occurs in 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; very slight progress in 15 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 30 minutes; very slight if any further advance in 45 and 60 minutes, respectively. (Chart D 234.)

The reaction with *nitric acid* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 18 per cent of the entire number of grains and 60 per cent of the total starch in 15 minutes; in about 45 per cent of the grains and 87 per cent of the total starch in 30 minutes; in about 69 per cent of the grains and 90 per cent of the total starch in 45 minutes; in about 78 per cent of the grains and 95 per cent of the total starch in 60 minutes. (Chart D 235.)

The hilum and lamellæ are very distinct, but less than in *N. sarniensis* var. *corusca major.* Gelatinization, as in *N. sarniensis* var. *corusca major,* begins at the hilum, and an equal number of the grains are less resistant at the proximal or at the distal end. The reaction is accompanied by considerably more granulation and fissuring than in *N. sarniensis* var. *corusca major,* and in the first-named starch the reaction is otherwise the same as in *N. sarniensis* var. *corusca major;* but in the last-named, 2 fissures extend from the hilum to the distal end, branching out somewhat as they near the margin. The starch included between the fissures becomes more hyaline in appearance and is divided into granules by the branching fissures, and as the hilum swells it is gelatinized from the hilum distally. The more resistant

material at the proximal end in the meantime forms a dense refractive band at the proximal margin and sides, and this is broken into granules by cracks from the margin and is gelatinized from the margin inward. The gelatinized grains are large, thin-walled, and usually somewhat less distorted than those of *N. sarniensis* var. *corusca major.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 77 per cent of the entire number of grains and 97 per cent of the total starch in 1 minute; in about 97 per cent of the grains and 99 per cent of the total starch in 3 minutes; in about 99 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 236.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 29 per cent of the entire number of grains and 76 per cent of the total starch in 5 minutes; in about 86 per cent of the grains and 98 per cent of the total starch in 15 minutes; in about 95 per cent of the grains and 99 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes, respectively. (Chart D 237.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 95 per cent of the entire number of grains and 97 per cent of the total starch in 3 minutes; in about 97 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes; in about 98 per cent of the grains and in more than 99 per cent of the total starch in 15 minutes. (Chart D 238.)

The reaction with *potassium iodide* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 0.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about the same percentage of the grains and 3 per cent of the total starch in 30 minutes; in about 1 per cent of the grains and 4 per cent of the total starch in 45 minutes; in about 2 per cent of the grains and 5 per cent of the total starch in 60 minutes. (Chart D 239.)

The hilum and lamellæ are distinct but not so distinct as in *N. sarniensis* var. *corusca major.* Gelatinization, as in *N. sarniensis* var. *corusca major,* begins at the hilum, which enlarges very slowly, and the starch immediately surrounding the hilum is divided by irregular, radiating fissures into granules; then 2 refractive fissures extend distally from the hilum, and these do not branch out and divide the surrounding material into granules, but extend straight down and enlarge as the hilum does. In the meantime the portion included between them becomes more hyaline and homogeneous in appearance and finally is gelatinized with some enlargement of the grain. The more resistant starch at the proximal end and sides forms a lamellated band which is invaded by cracks from the margin and so divided in rather fine granules. These may finally gelatinize, but do not always. In some grains one of the fissures extending from the hilum curves sidewise to the margin, and gelatinization first takes place here rather than at the distal end. The gelatinized grains, of which there are very few, are large and somewhat more distorted than in *N. sarniensis* var. *corusca major.*

The reaction with *potassium sulphocyanate* begins in a few grains immediately. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 3 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 4 per cent of the total starch in 30 minutes; very slight progress in 45 minutes; in about 2 per cent of the grains and 6 per cent of the total starch in 60 minutes. (Chart D 240.)

The hilum is as distinct as in *N. sarniensis* var. *corusca major,* and the lamellæ are less distinct than in *N. sarniensis* var. *corusca major* and do not remain distinct throughout the greater part of the reaction as in those grains. Gelatinization is preceded by the appearance in the interior of the grain of 2 fissures which extend from the hilum nearly to the distal margin. Gelatinization begins at the hilum as in *N. sarniensis* var. *corusca major* and proceeds in two ways, an approximately equal number of grains being gelatinized in each way. In one the distal starch is the least resistant, and becomes refractive in appearance, and is divided by branches from the two fissures, already mentioned, into fine granules, and then gelatinized from the hilum distally, while the more resistant proximal portion forms a thick non-striated, non-lamellated band which grows slowly thinner and more nearly transparent until all is gelatinized and only the thin capsule remains. In the other the process is the same as that described under *N. sarniensis* var. *corusca major.*

The gelatinized grains are large and as a rule somewhat less distorted than in *N. sarniensis* var. *corusca major,* and retain more of a resemblance to the form of the untreated grain.

The reaction with *potassium sulphide* begins immediately in a few grains. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 41 per cent of the total starch in 5 minutes; in about 37 per cent of the entire number of grains and 65 per cent of the total starch in 15 minutes; in about 58 per cent of the grains and 70 per cent of the total starch in 30 minutes; in about 66 per cent of the grains and 74 per cent of the total starch in 45 minutes; in about 69 per cent of the grains and 76 per cent of the total starch in 60 minutes. (Chart D 241.)

The hilum and lamellæ are distinct, but not so distinct as in *N. sarniensis* var. *corusca major.* Gelatinization begins at the hilum as in *N. sarniensis* var. *corusca major.* As the hilum begins to enlarge, 2 refractive fissures extend distally from the hilum towards the distal margin but do not branch out at all. The material at the proximal end is in a small majority the least resistant as in *N. sarniensis* var. *corusca major,* and gelatinization occurs there first, and then the distal starch is gelatinized without fissuring or granulation from the hilum outwards. Near the end of the reaction, when there is only a small mass of material remaining at the distal margin, some striation and granulation is noted, and in a few grains fine granules are formed from the material immediately surrounding the hilum, and these are more resistant than the rest of the grain. In

a somewhat large minority the distal starch is the least resistant and in these grains, there is always granulation of the portion immediately surrounding the hilum, but not much fissuring or granule formation elsewhere, than in *N. sarniensis* var. *corusca major*. There are fewer grains in which dissolution of one point in the capsules occurs than in *N. sarniensis* var. *corusca major*. The gelatinized grains are large and thin-walled and less distorted than in *N. sarniensis* var. *corusca major*.

The reaction with *sodium hydroxide* begins in a few grains in half a minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in less than 0.5 per cent of the grains and 2 per cent of the total starch in 30 minutes; in about 0.5 per cent of the grains and 3 per cent of the total starch in 45 minutes; in about 1 per cent of the grains and 4 per cent of the total starch in 60 minutes. (Chart D 242.)

The reaction with *sodium sulphide* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 3 per cent of the total starch in 30 minutes; slight advance in 45 minutes; in about 2 per cent of the grains and 4 per cent of the total starch in 60 minutes. (Chart D 243.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 78 per cent of the entire number of grains and 91 per cent of the total starch in 5 minutes; in 100 per cent of the grains and total starch in 10 minutes. (Chart D 244.)

The hilum becomes as distinct as in *N. sarniensis* var. *corusca major*, but the lamellæ are less distinct than in those grains. A narrow refractive band, which is not so narrow but more refractive than in *N. sarniensis* var. *corusca major*, is formed about the margins of the grains. Gelatinization begins usually first at the proximal end and then at the distal end, differing in this from *N. sarniensis* var. *corusca major* in which gelatinization usually does not begin at the distal end immediately following the gelatinization of the proximal end. Gelatinization is rather different from that in *N. sarniensis* var. *corusca major*, and progresses smoothly from the proximal end and from the distal end by serial separation and gelatinization of the lamellæ, and continues so until the most resistant part of the grain midway between the hilum and the distal end is reached, then the margin on either side is first rapidly gelatinized, then the central portion, accompanied by considerable infolding and invagination of the capsule at the proximal and distal ends. The gelatinized grains are large and more distorted than in *N. sarniensis* var. *corusca major*.

The reaction with *calcium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about 0.5 per cent of the grains and 2 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 4 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 245.)

The reaction with *uranium nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; slight advance in 30 minutes; in about the same percentage of the grains and 3 per cent of the total starch in 45 minutes; in about 2 per cent of the grains and 5 per cent of the total starch in 60 minutes. (Chart D 246.)

The reaction with *strontium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 12 per cent of the total starch in 5 minutes; in about 36 per cent of the grains and 78 per cent of the total starch in 15 minutes; in about 57 per cent of the grains and 86 per cent of the total starch in 30 minutes; in about 75 per cent of the grains and 93 per cent of the total starch in 45 minutes; in about 84 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 247.)

The reaction with *cobalt nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes. (Chart D 248.)

The reaction with *copper nitrate* begins in a few grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and 1 per cent of the total starch in 5 minutes; in about 0.5 per cent of the grains and 2 per cent of the total starch in 30 minutes; slight advance in 45 minutes; in about 1 per cent of the grains and 4 per cent of the total starch in 60 minutes. (Chart D 249.)

The reaction with *cupric chloride* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about the same percentage of the grains and 3 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes, respectively. (Chart D 250.)

The reaction with *barium chloride* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; very slight progress in 15 and 30 minutes; in less than 0.5 per cent of the grains and total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 251.)

The reaction with *mercuric chloride* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; slight advance in 15 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes, respectively. (Chart D 252.)

Nerine glory of sarnia (Hybrid).

(Plate 8, figs. 46 and 48; Charts D 232 to D 252.)

Histologic Properties.

In *form* the grains are usually simple and isolated, and there are fewer compound grains and aggregates than in either parent, in which respect this starch is nearer that of *N. sarniensis* var. *corusca major* than that of the other parent. When compound grains do occur they are of the types noted under *N. sarniensis* var. *corusca major* and a few such as are described under *N. curvifolia* var. *fothergilli major.* They are more regular in form than either parent, and any irregularities which occur are due to the following causes: (1) The greater development of one part of the distal end or of one side; (2) rounded protuberances from the sides or the ends, usually from the proximal end; (3) secondary sets of lamellæ whose longitudinal axes are at angles to the longitudinal axes of the primary sets; (4) notches and depressions in the margin particularly at the distal end; (5) deviation of the longitudinal axis with a consequent bending of the grain. The conspicuous forms are pure elliptical and elongated elliptical, and ovoid. There are also triangular, clam-shell, pyriform, round and nearly round, and lenticular forms. In form these grains are slightly nearer *N. sarniensis* var. *corusca major.* In form the parents and the hybrid are very close.

The *hilum* is as distinct as in *N. sarniensis* var. *corusca major,* and is rarely fissured, if the fissures are present they are of the same character as in *N. sarniensis* var. *corusca major.* The hilum is sometimes centric, but more often eccentric from 0.4 to 0.25, usually 0.32, of the longitudinal axis, less than in either parent. In character and eccentricity of the hilum those grains are closer *N. sarniensis* var. *corusca major* than to *N. fothergilli major.*

The *lamellæ* are not so distinct as in either parent, and there are more fine lamellæ than in either parent. In arrangement they resemble those of *N. sarniensis* var. *corusca major.* The number counted on the larger grains varies from 18 to 34, usually 28. In character, arrangement and number of the lamellæ these grains are nearer *N. sarniensis* var. *corusca major.*

In *size* the grains vary from the smaller which are 6 by 6μ and 10 by 8μ, to the larger elongated forms which are 44 by 36μ, and 44 by 32μ, and the larger rather rare broad forms which are 46 by 42μ, in length and breadth. The common sizes are 30 by 24μ and 30 by 20μ. The grains are closer *N. curvifolia* var. *fothergilli major* in size.

Polariscopic Properties.

The *figure* is nearly centric to eccentric, usually as eccentric and distinct and as clear-cut as in *N. sarniensis* var. *corusca major.* The lines are somewhat less coarse than in *N. sarniensis* var. *corusca major,* the same as in *N. curvifolia* var. *fothergilli major;* as in *N. sarniensis* var. *corusca major* they usually intersect obliquely, with but little variation of the angle, and are not often bent or bisected.

The *degree of polarization* varies from moderate to very high (value 90), the same as in *N. sarniensis* var. *corusca major.* It varies in different grains as in *N. sarniensis* var. *corusca major,* a few having a moderate, and the majority a high polarization.

With *selenite* the quadrants as in *N. sarniensis* var. *corusca major* are well defined, rarely of equal and usually of unequal size, and vary somewhat in shape. The colors are not quite as pure as in *N. sarniensis* var. *corusca major,* but less pure than in *N. curvifolia* var. *fothergilli major,* in this respect being closer to the other parent.

In degree of polarization, character of the figure, and appearances with selenite *N. glory of sarnia* is closer to *N. sarniensis* var. *corusca major* than to *N. curvifolia* var. *fothergilli major,* although the two parents and the hybrid all show a very close relationship.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains color a moderate blue with a tinge of violet (value 55), less than in *N. sarniensis* var. *corusca major,* and considerably less than in *N. curvifolia* var. *fothergilli major.* The color deepens rapidly until it is deep to very deep, as in *N. sarniensis* var. *corusca major.* With 0.125 per cent Lugol's solution the grains color a light to moderate blue with a tinge of violet. The color is less than in *N. sarniensis* var. *corusca major* and much less than in *N. curvifolia* var. *fothergilli major,* and it deepens rapidly as in *N. sarniensis* var. *corusca major.* After heating in water until the grains are gelatinized and then adding a 2 per cent Lugol's solution, the *grains* color a moderate to very deep indigo-blue the same as in *N. sarniensis* var. *corusca major;* the capsules can not be distinguished; and the *solution* colors a moderately deep indigo-blue as in *N. sarniensis* var. *corusca major.* If the preparation is boiled for 2 minutes, and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* color a light to very deep indigo-blue with a tinge of violet, as in *N. sarniensis* var. *corusca major;* the *capsules* pure violet as in *N. sarniensis* var. *corusca major;* and the *solution* a very deep indigo. Quantitatively and qualitatively the iodine reactions of *N. glory of sarnia* are closer to *N. sarniensis* var. *corusca major* than to *N. curvifolia* var. *fothergilli major.*

Aniline Reactions.

With *gentian violet* the grains stain lightly at once, and in half an hour they are light to moderately stained (value 35), less than either parent, but nearer to *N. sarniensis* var. *corusca major.*

With *safranin* the grains stain lightly at once, and in half an hour they are light to moderately stained (value 35), less than either parent, but nearer to *N. sarniensis* var. *corusca major.*

The aniline reactions of these grains show a closer relationship to *N. sarniensis* var. *corusca major* than to *N. curvifolia* var. *fothergilli major.*

Temperature Reactions.

The majority of the grains are gelatinized at 70 to 72° C., and all at 75.8 to 77° C., mean 76.4° C. The temperature of gelatinization of *N. glory of sarnia* is somewhat closer to *N. sarniensis* var. *corusca major* than to *N. curvifolia* var. *fothergilli major.*

EFFECTS OF VARIOUS REAGENTS.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 8 per cent of the entire number of grains and 14 per cent of the total starch in 5 minutes; in about 75 per cent of the grains and 77 per cent of the total starch in 15 minutes; in about 82 per cent of the grains and 86 per cent of the total starch in 30 minutes; in about 86 per cent of the grains and 89 per cent of the total starch in 45 minutes; in about 88 per cent of the grains and 90 per cent of the total starch in 60 minutes. (Chart D 232.)

The hilum and lamellæ are as distinct as in *N. sarniensis* var. *corusca major*, and a broad refractive band, which is as refractive as in *N. sarniensis* var. *corusca major*, is formed about the margins of the grains. Gelatinization, differing from the parents, begins much more frequently first at the proximal and then at the distal end, than first at the distal and then at the proximal end. The progress of gelatinization is somewhat closer to that described under *N. sarniensis* var. *corusca major*, as it is smoother and accompanied by less fissuring of the ungelatinized portion of the grain than in *N. curvifolia* var. *fothergilli major*, and the most resistant portion of the grain is nearer the distal margin than in *N. curvifolia* var. *fothergilli major*. The gelatinized grains are large and not so distorted as in *N. curvifolia* var. *fothergilli major*, but, as a rule, slightly more distorted than in *N. sarniensis* var. *corusca major*.

In the reaction with chloral hydrate *N. glory of sarnia* shows qualitatively a closer relationship to *N. sarniensis* var. *corusca major* than to *N. curvifolia* var. *fothergilli major*.

The reaction with *chromic acid* begins in rare grains in 1 minute. Complete gelatinization occurs in much less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; still in less than 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 30 per cent of the total starch in 30 minutes; in about 28 per cent of the grains and 78 per cent of the total starch in 45 minutes; in about 73 per cent of the grains and 94 per cent of the total starch in 60 minutes. (Chart D 233.)

The reaction with *pyrogallic acid* begins in very rare grains immediately. Complete gelatinization occurs in very rare grains and the process has begun in but few grains, less than 0.5 per cent of the grains and of the total starch in 5 minutes; slight advance in 15, 30, 45 minutes, but in 60 minutes only rare grains are completely gelatinized and the process has still begun in but few, less than 0.5 per cent, of the grains and total starch is gelatinized. (Chart D 234.)

The reaction with *nitric acid* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 20 per cent of the grains and 50 per cent of the total starch in 15 minutes; in about 37 per cent of the grains and 72 per cent of the total starch in 30 minutes; in about 45 per cent of the grains and 80 per cent of the total starch in 45 minutes; in about 55 per cent of the grains and 82 per cent of the total starch in 60 minutes. (Chart D 235.)

The hilum and lamellæ are as distinct as in *N. sarniensis* var. *corusca major*. Gelatinization, as in the parents, begins at the hilum, and there are many more grains that show the type of reaction described under *N. sarniensis* var. *corusca major* than under *N. curvifolia* var. *fothergilli major*, but a moderate number which show the process described for the second type of grains under *N. curvifolia* var. *fothergilli major*. In none of the grains, however, is there so much granulation and fissuration as in *N. curvifolia* var. *fothergilli major*. The gelatinized grains are large and thin-walled and usually as distorted as in *N. sarniensis* var. *corusca major*.

In the reaction with nitric acid *N. glory of sarnia* shows qualitatively a closer relationship to *N. sarniensis* var. *corusca major* than to *N. curvifolia* var. *fothergilli major*.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 60 per cent of the entire number of grains and 75 per cent of the total starch in 1 minute; in about 80 per cent of the grains and 92 per cent of the total starch in 3 minutes; in about 90 per cent of the grains and 96 per cent of the total starch in 5 minutes. (Chart D 236.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 20 per cent of the grains and 76 per cent of the total starch in 5 minutes; in about 72 per cent of the grains and 88 per cent of the total starch in 15 minutes; in about 84 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 95 per cent of the total starch in 45 minutes; and about 97 per cent of the total starch in 60 minutes. (Chart D 237.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 87 per cent of the entire number of grains and 94 per cent of the total starch in 3 minutes; in about 88 per cent of the grains and 96 per cent of the total starch in 5 minutes; in about 90 per cent of the grains and 98 per cent of the total starch in 15 minutes. (Chart D 238.)

The reaction with *potassium iodide* begins in a few grains in 1 minute. Complete gelatinization occurs in 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 3 per cent of the total starch in 15 minutes; very slight advance in 30 minutes; in about 2 per cent of the grains and 4 per cent of the total starch in 45 minutes; in about 3 per cent of the grains and 6 per cent of the total starch in 60 minutes. (Chart D 239.)

The hilum and lamellæ are as distinct as in *N. sarniensis* var. *corusca major*. Gelatinization, as in the parents, begins at the hilum, and the process is the same as that described in *N. sarniensis* var. *corusca major*. The gelatinized grains, of which there are very few, are large and as distorted as in *N. sarniensis* var. *corusca major*. *N. glory of sarnia* shows qualitatively, a closer relationship to *N. sarniensis* var. *corusca major* than to *N. curvifolia* var. *fothergilli major*.

The reaction with *potassium sulphocyanate* begins in a few grains immediately. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 0.5 per cent of the grains and 3 per cent of the total starch in 15 minutes; in about the same percentage of the grains and 4 per cent of the total starch in 30 minutes; in about 1 per cent of the grains and 5 per cent of the total starch in 45 minutes; in about 2 per

cent of the grains and 6 per cent of the total starch in 60 minutes. (Chart D 240.)

The hilum and lamellæ are as distinct as in *N. sarniensis* var. *corusca major*. Gelatinization begins at the hilum as in both parents, and the reaction in the great majority of the grains is the same as that described in *N. sarniensis* var. *corusca major*, and in a few is the same as that described for part of the grains of *N. curvifolia* var. *fothergilli major*. The gelatinized grains are large and the majority are as distorted as in *N. sarniensis* var. *corusca major*. *N. glory of sarnia* shows qualitatively a somewhat closer relationship to *N. sarniensis* var. *corusca major* than to *N. curvifolia* var. *fothergilli major*, but both the parents and the hybrid exhibit a very close relationship.

The reaction with *potassium sulphide* begins immediately in a few grains. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 24 per cent of the grains and 33 per cent of the total starch in 15 minutes; in about 41 per cent of the grains and 52 per cent of the total starch in 30 minutes; in about 48 per cent of the grains and 67 per cent of the total starch in 45 minutes; in about 50 per cent of the grains and 69 per cent of the total starch in 60 minutes. (Chart D 241.)

The hilum and lamellæ are distinct as in *N. sarniensis* var. *corusca major*. Gelatinization, as in the parents, begins at the hilum. In a large majority of the grains the process is the same as that described under *N. sarniensis* var. *corusca major*, except that there is more fissuring and granule formation than in those grains, and in a few it is the same as in *N. curvifolia* var. *fothergilli major* in which there was even less granulation than in *N. sarniensis* var. *corusca major*. The gelatinized grains are large and thin-walled and as distorted as in *N. sarniensis* var. *corusca major*. *N. glory* of *sarnia* is somewhat closer, qualitatively, to *N. sarniensis* var. *corusca major* than to *N. curvifolia* var. *fothergilli major*, although both parents and hybrid closely resemble one another.

The reaction with *sodium hydroxide* begins in a few grains in half a minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about the same percentage of the grains and 2 per cent of the total starch in 45 minutes; in about 1 per cent of the grains and 3 per cent of the total starch in 60 minutes. (Chart D 242.)

The reaction with *sodium sulphide* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and total starch in 15 minutes; in about the same percentage of the grains and total starch in 30 minutes; slight advance in 45 minutes; in less than 0.5 per cent of the grains and 2 per cent of the total starch in 60 minutes. (Chart D 243.)

The reaction with *sodium salicylate* begins in 1 minute. Complete gelatinization occurs in about 51 per cent of the entire number of grains and 74 per cent of the total starch in 5 minutes; in about 92 per cent of the grains and 97 per cent of the total starch in 10 minutes; in about 97 per cent of the grains and 99 per cent of the total starch in 15 minutes. (Chart D 244.)

The hilum becomes more distinct than in either parent, and the lamellæ are as distinct as in *N. sarniensis* var. *corusca major*, but more distinct than in *N. curvifolia* var. *fothergilli major*. A narrow refractive band, which is as refractive as in *N. sarniensis* var. *corusca major*, is formed about the margins of the grains. Gelatinization, as in *N. curvifolia* var. *fothergilli major*, may with almost equal frequency begin first at either the proximal or the distal end, but the progress of gelatinization is usually rather closer to that described under *N. sarniensis* var. *corusca major*, as the most resistant part of the grain is much nearer the distal end than in *N. curvifolia* var. *fothergilli major*, and there is not so much infolding and invagination of the capsule as in those grains. The gelatinized grains are large and somewhat more distorted than in *N. sarniensis* var. *corusca major*, but less than in *N. curvifolia* var. *fothergilli major*.

In this reaction *N. glory of sarnia* shows qualitatively a closer relationship to *N. sarniensis* var. *corusca major* than to *N. curvifolia* var. *fothergilli major*.

The reaction with *calcium nitrate* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and total starch in 15 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 2 per cent of the total starch in 45 minutes; little if any further change in 60 minutes. (Chart D 245.)

The reaction with *uranium nitrate* begins in a few grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about the same percentage of the grains and 2 per cent of the total starch in 30 minutes; slight advance in 45 minutes; in about 1 per cent of the grains and 4 per cent of the total starch in 60 minutes. (Chart D 246.)

The reaction with *strontium nitrate* in a few grains begins immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 33 per cent of the grains and 73 per cent of the total starch in 15 minutes; in about 58 per cent of the grains and 85 per cent of the total starch in 30 minutes; in about 71 per cent of the grains and 87 per cent of the total starch in 45 minutes; in about 75 per cent of the grains and 90 per cent of the total starch in 60 minutes. (Chart D 247.)

The reaction with *cobalt nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in much less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; still in less than 0.5 per cent of the grains and total starch in 15 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes, respectively. (Chart D 248.)

The reaction with *copper nitrate* begins in a few grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about the same percentage of the grains and

3 per cent of the total starch in 30 minutes; slight progress in 45 minutes; in about 1 per cent of the grains and 4 per cent of the total starch in 60 minutes. (Chart D 249.)

The reaction with *cupric chloride* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; little if any further advance in 30, 45, and 60 minutes, respectively. (Chart D 250.)

The reaction with *barium chloride* begins in rare grains in 2 minutes. Complete gelatinization occurs in much less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; little if any further change occurs after treatment with this solution for 15, 30, 45, and 60 minutes, respectively. (Chart D 251.) At the end of this period only rare grains are completely gelatinized and the reaction has begun in but few grains.

The reaction with *mercuric chloride* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; little if any further advance in 30, 45, and 60 minutes, respectively. (Chart D 252.)

6. NARCISSUS.

There are perhaps less than 20 known species belonging to this genus, but the number of cultivated forms, varieties, and hybrids is very large. In this research there are no recognized species among the parent-stocks, all of the parental specimens being horticultural varieties or hybrids. All of the bulbs were obtained from the growers, Barr & Sons, London, with the exception of *N. tazetta grand monarque* and *N. poetaz triumph*, which came from H. Krelage & Son, Haarlem, Holland. Of the following sets, set 14 was the only one that was fully studied.

13. *Narcissus poeticus ornatus* (seed parent), *N. poeticus poetarum* (pollen parent), *N. poeticus herrick* (hybrid), *N. poeticus dante* (hybrid), page 515.
14. *Narcissus tazetta grand monarque* (seed parent), *N. poeticus ornatus* (pollen parent), *N. poetaz triumph* (hybrid), page 527.
15. *Narcissus gloria mundi* (seed parent), *N. poeticus ornatus* (pollen parent), *N. fiery cross* (hybrid), page 536.
16. *Narcissus telamonius plenus* (seed parent), *N. poeticus ornatus* (pollen parent), *N. doubloon* (hybrid), page 542.
17. *Narcissus princess mary* (seed parent), *N. poeticus poetarum* (pollen parent), *N. cresset* (hybrid), page 548.
18. *Narcissus abscissus* (seed parent), *N. poeticus poetarum* (pollen parent), *N. will scarlet* (hybrid), page 554.
19. *Narcissus albicans* (seed parent), *N. abscissus* (pollen parent), *N. bicolor apricot* (hybrid), page 560.
20. *Narcissus empress* (seed parent), *N. albicans* (pollen parent), *N. madame de graaff* (hybrid), page 566.
21. *Narcissus weardale perfection* (seed parent), *N. madame de graaff* (pollen parent), *N. pyramus* (hybrid), page 572.
22. *Narcissus monarque* (seed parent), *N. madame de graaff* (pollen parent), *N. lord roberts* (hybrid), page 578.
23. *Narcissus leedsii minnie hume* (seed parent), *N. triandrus albus* (pollen parent), *N. agnes harvey* (hybrid), page 584.
24. *Narcissus emperor* (seed parent), *N. triandrus albus* (pollen parent), *N. j. t. bennett poe* (hybrid), page 591.

Particular interest is attached to the foregoing because of the same parent being used in some instances in several sets, sometimes as the seed parent and in others as the pollen parent, or always as either the seed or pollen parent; and also because of a hybrid being used as a parent.

13. Starches of Narcissus poeticus ornatus, N. poeticus poetarum, N. poeticus herrick, and N. poeticus dante.

Narcissus poeticus ornatus (Seed Parent).

(Plates 9, 10, and 11; figs. 9, 52, 56, 59, and 62; Charts D 253 to D 286.)

Histologic Properties.

In *form* the grains are usually simple and isolated, but there are a few compound grains and fewer aggregates. The compound grains belong to three types: (1) Doublets and triplets of equal size, whose method of formation probably is that 1 or 2 small grains become adherent to either the distal or the proximal end or the sides of a large grain, and all are inclosed in 2 or 3 common secondary lamellæ; (2) 2 small grains of equal size, adherent to one another at either sides or at their distal ends, are inclosed in 4 to 6 common secondary lamellæ; (3) rarely 8 or 9 hila in a homogeneous mass of starch surrounded by 3 or 4 secondary lamellæ. The aggregates are of 2, rarely 3, small grains linearly arranged, and occasionally of a compound grain and a simple grain, or of 2 compound grains. There are a number of grains in which a small, simple, primary grain may be seen which has later become inclosed in 3, 4, or more secondary lamellæ. The grains are somewhat irregular in form and the irregularities are due to the following causes: (1) Irregular depressions and elevations in the surface and margin; (2) poorly defined pressure facets on the distal end and sides; (3) more or less regular, radiating elevations and depressions of the surfaces, particularly at the distal end, giving a fluted appearance to the grains; (4) large protuberances, either pointed or rounded; (5) a notch or depression in the margin at the proximal end or one to either side of the proximal apex. The conspicuous forms are irregular ovoid, lenticular, quadrilateral and polygonal, triangular of various types, scalene, plano-convex, nearly round, and reniform. The additional forms are clam-shell-shaped, round, dome-shaped, and elongated elliptical. The grains are rarely flattened.

The *hilum* is usually fissured, otherwise it appears as a rather large, not very distinct, round or lenticular spot. The fissures are deep but not very extensive and often branched and irregular, and have the following forms: (1) A single, long transverse or longitudinal cleft which may be either straight or slightly bent or curved; (2) cruciate, Y- or T-shaped; (3) an irregular mass of short branched fissures extending from the hilum toward the distal end. It is sometimes centric, but as a rule eccentric from 0.45 to 0.25, usually 0.34, of the longitudinal axis.

The *lamellæ* are moderately distinct, coarse, continuous rings, which all follow in general the form of the outline of the grain, but only near the margin do they conform to the irregularities of the contour. In those grains which have both primary and secondary starches they are usually distinct in the secondary portion and usually invisible or indistinct in the primary

part. The number counted on some of the larger grains varies from 6 to 12, usually 9.

The *size* of the grains varies from the smaller which are 4 by 4μ, to the larger broad forms which are 30 by 40μ, and the larger slender forms which are 40 by 34μ, in length and breadth. The common sizes are 22 by 24μ, 24 by 24μ and 22 by 18μ.

Polariscopic Properties.

The *figure* is usually distinct, but in a moderate number of grains it is somewhat indistinct. The lines are rather broad and not very clear-cut, they usually intersect at an acute angle which is not very variable in different grains. There are sometimes 5 lines, and the lines are occasionally bisected, but they are rarely bent or otherwise irregular. The figure is usually a cross but occasionally takes the form of a conjugate hyperbole.

The *degree of polarization* varies from low to very high, and most of the grains have a moderate degree of polarization (value 50). There is often some variation in the same aspect of a given grain.

With *selenite* the quadrants are usually not well defined and commonly unequal in size and regular in shape. The colors are generally not pure, the yellow being less pure than the blue. A few of the grains have a greenish tinge.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains at once stain a light to moderate violet tinged with blue (value 40). The color deepens with moderate rapidity until it is very deep, becoming more bluish in tint. All the grains are equally stained. With 0.125 per cent Lugol's solution the grains color pure violet very lightly, and the color deepens with moderate rapidity until they are deeply colored. After heating in water until all the grains are gelatinized, and then adding 2 per cent Lugol's solution, the gelatinized *grains* all color a moderate to moderately deep indigo; the *solution* is colored a moderately deep indigo-blue. If the preparation is boiled for 2 minutes, and then treated with an excess of 2 per cent Lugol's solution, most of the *grain-residues* color a moderate indigo-blue, and a few light indigo; the *capsules* color a red or a reddish violet; and the *solution* a very deep indigo-blue.

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in half an hour they are light to moderately colored (value 30). The grains are all stained with equal intensity, and there is no variation in the same aspect of the individual grains.

With *safranin* the grains all color very lightly at once, and in half an hour they are moderately colored (value 45). The grains are all stained with equal intensity, and there is no variation in the same aspect of the individual grains.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 73° to 74° C., and of all is 77° to 78° C., mean 77.5° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 3 per cent of the grains and 6 per cent of the total starch in 15 minutes; in about 16 per cent of the grains and 24 per cent of the total starch in 30 minutes; in about 20 per cent of the grains and 28 per cent of the total starch in 45 minutes; in about 27 per cent of the grains and 34 per cent of the total starch in 60 minutes. (Chart D 259.)

The *hilum* is not distinct, except in a rather large minority of the grains in which a small bubble is formed, which remains unchanged until the reaction is nearly completed. The lamellæ are at first indistinct, but gradually become moderately distinct in most of the grains. The grains grow somewhat more refractive in appearance after the addition of the reagent, and the first part to show the increased refractivity is a rather narrow band of starch at the margin of the grains. Gelatinization in all the grains, except those which are lenticular in shape, begins at various points, usually the ends of protuberances on the distal margin, and from these points extends to two or three marginal lamellæ which have been separated from the rest of the grain, except a small portion at the proximal end. The rest of the grain now assumes a pitted appearance and, as gelatinization proceeds inward, is invaded by fissures which separate granules from the ungelatinized starch. In this manner gelatinization progresses until the hilum is reached, the bubble first swells, then shrinks, and finally disappears, and the hilum swells and the material at the proximal end which is the last to react is quickly gelatinized. The lenticular grains are first divided into two parts by a broad refractive fissure in the long axis of the grain and then gelatinization begins at the margin at either end of this fissure and proceeds smoothly toward the center, in which is the hilum. When this is reached the hilum swells suddenly and the hitherto ungelanized portion immediately surrounding it is quickly gelatinized.

The gelatinized grains are much swollen and have moderately thin capsules. They are very much distorted and do not retain any resemblance to the form of the untreated grain.

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 65 per cent of the total starch in 15 minutes; in about 27 per cent of the grains and 80 per cent of the total starch in 30 minutes; in about 44 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 60 per cent of the grains and 98 per cent of the total starch in 60 minutes.* (Chart D 260.)

*This reagent gelatinizes the mesial portion much more rapidly than the margin, as is very generally the case with starches with this reagent. The margin is much more resistant in some grains than in others, hence the differentiation of the starches is much more marked in the percentage of complete gelatinization than in the total gelatinization. The amount of starch at the margin varies considerably in different grains; this represents one-third, one-fourth, one-fifth to about one-twentieth of the entire grain, and hence, while in some starches the percentage of the grains gelatinized is quite low, that of the total starch is high. There was found to be such a difference in the complete gelatinization of *N. poeticus ornatus* and the other members of this set that the experiments with this reagent were repeated with practically absolutely identical results.

The hilum is distinct and a bubble is never formed there. The lamellæ are moderately distinct in some grains and indistinct or invisible in others. Gelatinization begins at the hilum. First the starch immediately around the hilum is divided into particles or large granules, and longitudinal fissures extend irregularly from the hilum to the distal margin, dividing the material in their path into granules of varying size. The material not included in this fissuring becomes coarsely striated. The grains now begin to swell and the less resistant portion is gelatinized, especially the granular matter between the hilum and the distal margin. The more resistant starch is pushed to the margin, where it forms a band which extends all the way or only part of the way around the margin and consists of two parts—an outer, refractive, coarsely striated, lamellated ring, and an inner, less refractive, spicular ring with a fringed inner border that incloses coarse granules. As fast as these granules are gelatinized, others are formed from the fringed inner band, which are gelatinized. Finally, only the outer, striated, lamellated band is left, and in the grains in which gelatinization is complete before dissolution occurs, the striæ become at first coarser and more distinct, while the lamellated appearance disappears, then the striæ become indistinct, and finally only a nearly transparent and homogeneous-looking capsule is left. In a few grains in which there is a very clear distinction between primary and secondary starch deposits, the former is broken into 3 or 4 large particles which are scattered around the inner border of the marginal band, which in these grains consists of only one portion which is coarsely striated and lamellated. The particles of the primary starch in such grains are very resistant and the last part of the grain to be gelatinized.

The gelatinized grains are much swollen, have rather thick capsules, and are not much distorted. Usually, however, the capsule is dissolved in one place before the rest of the grain is completely gelatinized and the contents of the capsule are gelatinized and flow out and are dissolved, leaving only the thin capsule which first separates into several pieces and then is dissolved.

The reaction with *pyrogallic acid* begins in a few grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 20 per cent of the total starch in 15 minutes; in about 22 per cent of the grains and 68 per cent of the total starch in 30 minutes; in about 38 per cent of the grains and 81 per cent of the total starch in 45 minutes; in about 48 per cent of the grains and 88 per cent of the total starch in 60 minutes. (Charts D 261 and D 262.)

The hilum is distinct and a bubble is never formed there. The lamellæ are moderately distinct in some grains, very distinct in some, and not distinct in the others. Gelatinization begins at the hilum and progresses according to two methods. In the great majority of the grains the starch immediately surrounding the hilum is split into a great number of rather coarse granules, and the rest of the material of the grain is divided by very fine striæ. The less resistant portion of the grain is gelatinized and the grain swells, slowly pushing the more resistant starch to the margin where it forms a finely striated, lamellated band, around the inner border of which are arranged the granules formed from the material immediately surrounding the hilum, which in some cases at least certainly represents a primary starch formation. These granules are very resistant; they slowly grow smaller and more refractive and often remain for some time after the rest of the grain is gelatinized. In the marginal band the lamellated appearance, if present, shortly disappears and two layers may be distinguished—an inner spicular portion and an outer striated portion. The inner portion is gelatinized first and then the outer becomes thinner, more homogeneous-looking and more nearly transparent until finally it is also gelatinized and only the capsule is left. In the second method 2 furrows or actual fissures extend transversely or obliquely from the hilum to the margin on either side and the material included between them and the hilum and the distal margin loses all its definite structural appearance and becomes a nearly homogeneous, hyaline-looking mass which is invaded at the margin by short cracks. The starch at the proximal end and sides forms fine striated bands at the margin. The portion distal to the hilum is slowly gelatinized with some swelling but not much distortion, the short fissures or cracks at the margin remaining visible for a long time. The proximal material gelatinizes more slowly but finally only a row of refractive granules remains at the margin which very slowly disappear.

The gelatinized grains are much swollen and have moderately thick capsules. They are somewhat distorted but retain some resemblance to the form of the untreated grain.

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in but rare grains, less than 0.5 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 11 per cent of the grains and 20 per cent of the total starch in 15 minutes; in about 16 per cent of the grains and 39 per cent of the total starch in 30 minutes; in about 21 per cent of the grains and 65 per cent of the total starch in 45 minutes; in about 25 per cent of the grains and 70 per cent of the total starch in 60 minutes. (Chart D 263.)

The hilum is distinct and a bubble is not formed there in any of the grains. The lamellæ are distinct at first but later are obscured. Gelatinization begins at the hilum and proceeds according to three methods. In the great majority of the grains the starch immediately around the hilum, which probably represents a primary starch formation, is split into fragments of varying shape, number, and size, and the portion surrounding it, which probably represents a secondary starch formation, is divided by fine striæ, partially gelatinized and swells, pushing the more resistant part to the margin where it forms a broad, lamellated, coarsely striated, marginal band, around the inner border of which are arranged the segments of the primary starch. These last are very resistant, and though they grow progressively smaller and more refractive they usually remain for some time after the rest of the grain is gelatinized. In the marginal band the lamelated appearance shortly disappears and two portions may be distinguished—an inner, spicular, refractive, and an outer, granular, less-refractive portion. The inner segment is gelatinized moderately rap-

idly, and the outer row of granules persists for some time, but finally disappears. In the second type 2 furrows or actual fissures are formed running transversely or obliquely from the hilum to the margin and the material included between them and the hilum and the distal margin, which comprises the greater part of the grain, is divided into a fine granular mass in which the granules are arranged in rows corresponding to the lamellæ, which, as gelatinization and swelling begin, loses the lamellar arrangement and is invaded at the margin by many short, straight fissures. The material at the proximal end meantime forms a distinctly striated band at the proximal margin and sides nearby. Gelatinization proceeds more rapidly in the distal granular mass from the hilum to the margin and is accompanied by much swelling and considerable distortion of the capsule. The proximal starch gelatinizes more slowly and finally only a row of refractive granules remains at the margin, which very slowly disappears. The third type of gelatinization is the same as the first except that there is no division into primary and secondary starch, and therefore there is no formation of resistant particles around the hilum.

The gelatinized grains are much swollen, have moderately thin capsules, and are somewhat distorted but retain some resemblance to the form of the untreated grain. Some grains show partial dissolution at one or many places before gelatinization is complete.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 71 per cent of the entire number of grains and 93 per cent of the total starch in 2 minutes; in about 97 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes; in about 99 per cent of the grains and more than 99 per cent of the total starch in 10 minutes. (Chart D 264.)

The hilum is distinct and a rather large bubble is often present. The lamellæ are moderately distinct in some grains but not visible in the majority. Gelatinization begins at the hilum and progresses according to two methods. In the majority of the grains the starch immediately surrounding the hilum is split into three or four pieces and the bubble, if present, swells, then shrinks, and disappears; the grains begins to swell and the remainder of the substance is pushed to the margin as a homogeneous-looking, refractive band, while the three or four pieces of starch in the center of the grain are converted into a mass of fine granules and soon gelatinized, the marginal band becomes thinner and more refractive, and finally is gelatinized, leaving only the capsule; in some grains a fissure is formed separating the primary from the secondary starch, and the latter is partially separated into concentric groups of lamellæ, which are later fused in the marginal band; from this point inward the progress is similar to that already described. In the second method 2 furrows or actual fissures extend transversely, or sometimes obliquely, from either side of the hilum nearly to the margin and the material between them, the hilum and the margin is transformed into a finely granular mass which often shows somewhat of a lamellar arrangement. This is quickly lost, however, and the whole melts down into a gelatinous mass with much swelling. In the meantime the more resistant material at the proximal end and sides nearby is pushed to the margin, where it forms a homogeneous-looking, rather refractive marginal band which grows progressively thinner and more nearly transparent until all the material composing it is gelatinized and only the capsule is left.

The gelatinized grains are much swollen and have moderately thick capsules. They are considerably distorted and do not bear much resemblance to the form of the untreated grain.

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 23 per cent of the entire number of grains and 88 per cent of the total starch in 5 minutes; in about 54 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 70 per cent of the grains and 97 per cent of the total starch in 30 minutes; in about 80 per cent of the grains and 98 per cent of the total starch in 45 minutes; in about 88 per cent of the grains and 99 per cent of the total starch in 60 minutes. (Chart D 271.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 19 per cent of the total starch in 5 minutes; in about 13 per cent of the grains and 36 per cent of the total starch in 15 minutes; in about 16 per cent of the grains and 43 per cent of the total starch in 30 minutes; in about 23 per cent of the grains and 48 per cent of the total starch in 45 minutes; in about 25 per cent of the grains and 53 per cent of the total starch in 60 minutes. (Chart D 272.)

The reaction with *potassium iodide* begins in half a minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 11 per cent of the grains and 51 per cent of the total starch in 15 minutes; in about 22 per cent of the grains and 68 per cent of the total starch in 30 minutes; in about 36 per cent of the grains and 77 per cent of the total starch in 45 minutes; in about 44 per cent of the grains and 80 per cent of the total starch in 60 minutes. (Chart D 273.)

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 8 per cent of the entire number of grains and 45 per cent of the total starch in 5 minutes; in about 40 per cent of the grains and 70 per cent of the total starch in 15 minutes; in about 60 per cent of the grains and 80 per cent of the total starch in 30 minutes; in about 68 per cent of the grains and 90 per cent of the total starch in 45 minutes; in 73 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 274.)

The reaction with *potassium sulphide* begins in rare grains in half a minute. Complete gelatinization was not observed in any of the grains and gelatinization occurs in about 1 per cent of the total starch in 5 minutes; slight advance in 15 minutes; in less than 0.5 per cent of the grains and 2 per cent of the total starch in 30 minutes; in about 1 per cent of the grains and 4 per cent of the total starch in 45 minutes; in about the same of both the grains and total starch in 60 minutes. (Chart D 275.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 18 per cent of the total starch in 5 minutes; in about 24 per cent of the

grains and 49 per cent of the total starch in 15 minutes; in about 36 per cent of the grains and 62 per cent of the total starch in 30 minutes; in about 50 per cent of the grains and 75 per cent of the total starch in 45 minutes; in about 60 per cent of the grains and 80 per cent of the total starch in 60 minutes. (Chart D 276.)

The reaction with *sodium sulphide* begins in about half a minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 12 per cent of the total starch in 15 minutes; in about 12 per cent of the grains and 33 per cent of the total starch in 30 minutes; in about 20 per cent of the grains and 53 per cent of the total starch in 45 minutes; in about 27 per cent of the grains and 56 per cent of the total starch in 60 minutes. (Chart D 277.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 27 per cent of the entire number of grains and 50 per cent of the total starch in 5 minutes; in about 90 per cent of the grains and 92 per cent of the total starch in 15 minutes; in over 99 per cent of both the grains and total starch in 30 minutes. (Chart D 278.)

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 9 per cent of the total starch in 15 minutes; in about 6 per cent of the grains and 19 per cent of the total starch in 30 minutes; in about 14 per cent of the grains and 43 per cent of the total starch in 45 minutes; in about 17 per cent of the grains and 53 per cent of the total starch in 60 minutes. (Chart D 279.)

The reaction with *uranium nitrate* begins in but few grains in 1 minute. Complete gelatinization of any of the grains was not observed and about 1 per cent of the total starch was gelatinized in 5 minutes; less than 0.5 per cent of the entire number of grains gelatinized and 5 per cent of the total starch in 15 minutes; complete gelatinization occurs in about 2 per cent of the entire number of grains and 7 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 10 per cent of the total starch in 45 minutes; in about the same percentage of grains and total starch (12 per cent) in 60 minutes. (Chart D 280.)

The reaction with *strontium nitrate* begins in a few grains in half a minute. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 13 per cent of the grains and 42 per cent of the total starch in 15 minutes; in about 24 per cent of the grains and 55 per cent of the total starch in 30 minutes; in about 37 per cent of the grains and 63 per cent of the total starch in 45 minutes; in about 38 per cent of the grains and 66 per cent of the total starch in 60 minutes. (Chart D 281.)

The reaction with *cobalt nitrate* begins in rare grains in 1 minute. Complete gelatinization was not observed in any of the grains, and in 0.5 per cent of the total starch in 5 minutes; complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 15 minutes; in about the same percentage of the grains and 3 per cent of the total starch in 30 minutes; little if any further progress in 45 and 60 minutes, respectively. (Chart D 282.)

The reaction with *copper nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 8 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 9 per cent of the total starch in 30 minutes; in about 2 per cent of the grains and 10 per cent of the total starch in 45 minutes; in about 3 per cent of the grains and 15 per cent of the total starch in 60 minutes. (Chart D 283.)

The reaction with *cupric chloride* begins in a few grains in 1 minute. Complete gelatinization was not observed in any of the grains and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 4 per cent of the total starch in 30 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 45 minutes; in about 4 per cent of the grains and 6 per cent of the total starch in 60 minutes. (Chart D 284.)

The reaction with *barium chloride* begins in a few grains (a slight deepening of the fissures) in 2 minutes. Complete gelatinization was not observed in any of the entire number of grains and has begun in but few grains in 5 minutes; very slight if any advance occurs in 15, 30, 45, and 60 minutes, respectively. Perhaps about 1 per cent of the total starch is gelatinized. (Chart D 285.)

The reaction with *mercuric chloride* begins in rare grains in 1 minute. Complete gelatinization was not observed in any of the entire number of grains and the reaction was begun in very few in 5 minutes; complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 4 per cent of the total starch in 30 minutes; slight advance in the grains and the total starch in 45 minutes; in about 2 per cent of the grains and 7 per cent of the total starch in 60 minutes. (Chart D 286.)

Narcissus poeticus poetarum (Pollen Parent).

(Plates 9, 11, and 12, figs. 50, 53, 65, and 68; Charts D 259 to D 264.)

Histologic Properties.

In *form* the grains are usually simple and isolated, but compound grains occur somewhat more frequently than in *N. poeticus ornatus,* and aggregates as frequently as in that starch. The compound grains belong to the same three types as have been noted under *N. poeticus ornatus*: (1) Most frequently, 2 or 3 equal-sized, small grains inclosed by 2 or 3 common secondary lamellæ; (2) 1 or 2 small grains adherent to the sides or either end of a large grain and all inclosed by 1 to 3 common secondary lamellæ; (3) 4 or more hila embedded in a homogeneous-looking, central mass of starch, surrounded by 2 or 3 lamellæ. The aggregates usually consist of 2 or 3 small grains linearly arranged. While the total number of aggregates is about the same there are more aggregates formed of compound grains, or of a compound and 1 simple grain, than in *N. poeticus ornatus;* and also a larger number of simple primary grains which have later been inclosed in several layers of a secondary starch deposit. The grains are more irregular than are

those of *N. poeticus ornatus*, and the irregularities are due to the same causes: (1) Irregular depressions and elevations in the surface and margin; (2) more grains with small, irregular, rounded protuberances from various points on the margin; (3) pressure facets at the distal end and sides; (4) fewer regular depressions and elevations of the surface giving a fluted appearance; (5) the same number of grains, with a small notch at the proximal end, or 2 small notches, one on each side of the proximal apex. The conspicuous forms are irregular ovoid, slender lenticular, plano-convex, dome-shaped, nearly round, scalene-triangular and other triangular forms, and slender elliptical. The additional forms are irregularly polygonal, clam-shell-shaped, pyriform, and reniform. The grains are not flattened.

The *hilum* is even more often fissured than in *N. poeticus ornatus*, and when not fissured it appears as a rather small, round, or lenticular spot which is not so distinct as in *N. poeticus ornatus*. The fissures are as deep and even more extensive, but less often branched, than in *N. poeticus ornatus* and have the following forms: (1) Cruciate-, T-, or Y-shaped; (2) an irregularly stellate group of fissures radiating in all directions from the hilum; (3) a single, straight, transverse, or oblique line. The hilum is sometimes centric, but is commonly eccentric from 0.45 to 0.28, usually 0.38, of the longitudinal axis.

The *lamellæ* are not so distinct or so coarse as in *N. poeticus ornatus*, and conform in general to the shape of the outline of the grain, but only near the margin do they follow the irregularities of the contour. In the grains which have both primary and secondary starch, they are usually moderately distinct in the secondary portion and invisible in the primary deposit. The number counted on some of the larger grains varies from 8 to 18, usually 12.

In *size* the grains vary from the smaller which are 5 by 5μ, to the larger broad forms which are 50 by 50μ, and 46 by 50μ, and the rare larger elongated forms, which are 46 by 38μ. The common sizes are 32 by 30μ and 30 by 34μ.

Polariscopic Properties.

The *figure* is usually distinct, but is even less often well defined than in *N. poeticus ornatus*. The lines intersect one another at angles of widely varying size and are much more apt to be bisected and bent than in *N. poeticus ornatus*. The figure also much less often has the form of a cross in *N. poeticus ornatus*—hyperbolas and longitudinal lines bisected at both ends being not uncommon.

The *degree of polarization* varies from low to very high (value 40). The value is less than in *N. poeticus ornatus* as there are fewer grains in which the degree of polarization is very high. There is also more variation in the same aspect of a given grain.

With *selenite* the quadrants are not well defined and are more irregular in shape and unequal in size than in *N. poeticus ornatus*. The colors are not so pure, and there are fewer grains in which a greenish tinge is observed than in *N. poeticus ornatus*.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains color a moderate violet tinged with blue (value 45), somewhat deeper and with more of a bluish tint than in *N. poeticus ornatus*. The color deepens with moderate rapidity until it is very deep, becoming, at the same time, more bluish in tint. With 0.125 per cent Lugol's solution, the grains color a light violet, not so light as in *N. poeticus ornatus*. The color deepens with moderate rapidity until the grains are deeply colored, assuming more of a bluish tinge than in *N. poeticus ornatus*. After heating in water until all the grains are gelatinized and then adding a 2 per cent Lugol's solution, the gelatinized *grains* all color a moderate indigo, less than in *N. poeticus ornatus;* and the *solution* a deep indigo-blue, more than in *N. poeticus ornatus*. If the preparation is boiled for 2 minutes, and then treated with an excess of 2 per cent Lugol's solution, most of the *grain-residues* color a light to moderate indigo-blue, less than in *N. poeticus ornatus*, and in a few only the capsules are colored. The *capsules* all color a red or reddish violet, and the *solution* a very deep indigo-blue, the same as in *N. poeticus ornatus*.

Aniline Reactions.

With *gentian violet* the grains color very lightly at once, and in half an hour they are light to moderately colored (value 35), somewhat more than in *N. poeticus ornatus*. The grains are all stained with equal intensity, and there is no variation in the same aspect of an individual grain.

With *safranin* the grains color very lightly at once, and in half an hour they are moderately colored (value 50), somewhat more than in *N. poeticus ornatus*. The grains are all stained with equal intensity, and there is no variation in the same aspect of the individual grain.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 67° to 69° C., and of all is 71° to 73° C., mean 72° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 3 per cent of the grains and 6 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 9 per cent of the total starch in 30 minutes; in about 6 per cent of the grains and 11 per cent of the total starch in 45 minutes; in about 10 per cent of the grains and 17 per cent of the total starch in 60 minutes. (Chart D 259.)

The hilum is indistinct except in the few grains in which a rather large bubble is formed. The lamellæ are at first indistinct, but gradually become moderately distinct in most of the grains as in *N. poeticus ornatus*. The grains become more refractive in appearance after the addition of the reagent, and the first part to be so affected is a rather narrow band of starch at the margin which is narrower and less refractive than a similar band in *N. poeticus ornatus*. Gelatinization begins at various discrete points on the margin and proceeds in two ways. The method seen in the majority of the grains is very similar to that described for the grains of *N. poeticus ornatus*. The marginal material is gelatinized nearly to the proximal end on either side, without, however, being partially separated from the rest of the grain by a fissure as in *N. poeticus ornatus*. Gelatinization now proceeds inward, the ungelatinized starch assumes a

pitted appearance and is invaded by numerous fissures, which split off small granules which in turn float off and are gelatinized. There is more of this fissuring and granule formation than in *N. poeticus ornatus.* When the hilum is reached it swells suddenly, and the bubble, if present swells, shrinks, and finally disappears, and the proximal starch is rapidly gelatinized. In the second method gelatinization begins at several points on the margin and does not spread around the margin, but proceeds inward from each point, forming cup-shaped hollows in the grains which finally coalesce, when the hilum is nearly reached. From this point the reaction is the same as that in the first method. In the lenticular-shaped grains, as in *N. poeticus ornatus,* gelatinization begins at the margin at either end of the long axis, and proceeds smoothly toward the hilum which is centrally situated. The hilum when reached swells suddenly and rapidly, and the starch immediately surrounding it is rapidly gelatinized.

The gelatinized grains are as much swollen and have thinner capsules than in *N. poeticus ornatus.* They are as in that starch much distorted and do not bear any resemblance to the form of the untreated grain.

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 22 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 65 per cent of the total starch in 30 minutes; in about 5 per cent of the grains and 75 per cent of the total starch in 45 minutes; in about 10 per cent of the grains and 85 per cent of the total starch in 60 minutes. (Chart D 260.) (See footnote, page 516.)

The hilum is distinct and the lamellæ are not so frequently distinct as in *N. poeticus ornatus.* Gelatinization begins at the hilum and follows two methods. In the first method of gelatinization 2 furrows extend horizontally from the hilum toward the margin and the fissures present at the hilum widen and deepen and in many cases divide the grain into various parts as they extend nearly to the margin. The portion of the grain comprehended between the furrows, the hilum, and the margin becomes finely granular and the proximal material is coarsely striated but rarely lamellated. The granular portion gelatinizes first and from this point onward the reaction is the same as that described under the second method. In the second which resembles one described in *N. poeticus ornatus,* a number of fissures extends from the hilum to the distal margin dividing the starch in their path into irregular granules and leaving only the proximal end and sides nearby unfissured. The fissures are not so coarse but are more numerous and split the material into finer granules than in *N. poeticus ornatus.* The proximal starch is pushed to the margin as the grain swells and is coarsely striated but rarely lamellated, and shows only one layer. The granular material between the hilum and the distal end is the first to be gelatinized from the hilum outward. This is accompanied by considerable swelling, and in the meantime the proximal starch is becoming more refractive and thinner and is gradually losing its striated appearance until only a rather thin, homogeneous-looking capsule is left, which has been dissolved at the distal margin.

The gelatinized grains are much swollen, have thinner capsules, and are more distorted than in *N. poeticus ornatus,* but as frequently as in *N. poeticus ornatus* are the capsules dissolved at one point. Before gelatinization is complete, the contents flow out and are dissolved, and the capsule is separated into two or three pieces and dissolved.

The reaction with *pyrogallic acid* begins in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the grains and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 16 per cent of the total starch in 15 minutes; in about 16 per cent of the grains and 70 per cent of the total starch in 30 minutes; in about 36 per cent of the grains and 84 per cent of the total starch in 45 minutes; in about 48 per cent of the grains and 93 per cent of the total starch in 60 minutes. (Chart D 262.)

The hilum is distinct, but the lamellæ are less often distinct than in *N. poeticus ornatus.* Gelatinization begins at the hilum and progresses according to two methods which are very similar to the two described under *N. poeticus ornatus.* In a small majority of the grains 2 furrows (or in many grains actual fissures) proceed transversely or obliquely from either side of the hilum to the margin, and the starches included between them and the hilum and the distal end becomes more refractive and assumes an irregularly pitted appearance and is then fissured, somewhat irregularly, from the hilum out to the margin. Meanwhile the material at the proximal end and sides nearby becomes striated, and in some grains shows a lamellar structure. The distal material which becomes more and more homogeneous-looking begins to gelatinize slowly with some swelling and distortion. The proximal material which forms a band at the margin slowly becomes more refractive and homogeneous-looking and finally is also gelatinized. In the second method, which is similar to that described for the majority of the grains of *N. poeticus ornatus* and which occurs in a moderate number of the grains of starch, the mesial portion of the grains which probably represents a primary starch formation is divided by irregular fissures into a number of rather coarse granules which are finer, as a rule, than those in *N. poeticus ornatus;* while the rest of the starch, which represents a secondary formation, becomes finely striated and (as the less resistant material is gelatinized) swells, pushing the more resistant material to the margin where it forms a striated and but rarely a lamellated band, around the inner border of which are arranged the granules of the primary starch. The marginal material slowly grows thinner and more nearly transparent and finally is completely gelatinized leaving only the capsule. The granules of the primary starch, however, often persist for a long time. The gelatinized grains are more swollen, and the capsules are thinner and more distorted than in *N. poeticus ornatus.*

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 40 per cent of the total starch in 15 minutes; in about 13 per cent of the grains and 53 per cent of the

total starch in 30 minutes; in about 23 per cent of the grains and 60 per cent of the total starch in 45 minutes; in about 30 per cent of the grains and 63 per cent of the total starch in 60 minutes. (Chart D 263.)

The hilum is distinct as in *N. poeticus ornatus,* and the lamellæ are at first not so distinct, and later are obscured. Gelatinization begins at the hilum and two methods of procedure are noted similar to two already described under *N. poeticus ornatus.* In a small majority of the grains 2 furrows or in many cases actual fissures proceed transversely or obliquely from the hilum to the margin, and the material comprehended between them and the hilum and the distal margin becomes more refractive and assumes an irregularly pitted appearance, then is criss-crossed by fissures of varying degree of distinctness. The starch at the proximal end and sides nearby meanwhile becomes striated but shows no lamellar structure. Then the refractive, fissured, distal portion gelatinizes moderately rapidly from the hilum outward toward the margin, with more irregular swelling and distortion than in *N. poeticus ornatus.* The proximal material gelatinizes more slowly but is not divided into two parts as in *N. poeticus ornatus,* but is usually divided into granules which slowly disappear. In the second method which is similar to that described for the majority of grains in *N. poeticus ornatus,* and which occurs in a moderate number of grains of this starch, the inner portion of the grain which probably represents the primary starch formation is divided by irregular fissures into segments which are finer, as a rule, than those noted in *N. poeticus ornatus,* while the outer surrounding portion of the grain which probably represents a secondary starch formation is gelatinized more rapidly and swells, pushing the more resistant material to the margin where it forms a finely striated, faintly lamellated band. The broken subdivided segments of the primary starch are arranged irregularly around the inner border of this band. The marginal starch slowly grows thinner and more nearly transparent until a single row of fine granules alone remains and these also finally disappear. The inner granules, however, persist for a long time in some grains.

The gelatinized grains are more swollen and the capsule is thinner and much more distorted than in *N. poeticus ornatus.* There are fewer grains in which dissolution takes place before gelatinization is complete than in *N. poeticus ornatus.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 54 per cent of the entire number of grains and 79 per cent of the total starch in 2 minutes; in about 93 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes; in more than 99 per cent of the grains and total starch in 10 minutes. (Chart D 264.)

The hilum is distinct, and while a bubble is often formed there it is not so frequently as in *N. poeticus ornatus.* The lamellæ are not quite so distinct. Gelatinization begins at the hilum and progresses according to two methods which are very similar to those described under *N. poeticus ornatus.* In the first, which is to be seen in the great majority of the grains, even in most of those which show a clear distinction between the primary and secondary starch formations, 2 furrows or actual fissures extend transversely, rarely obliquely, from either side of the hilum nearly to the margin, and in the portion of the grain included between them the lamellæ are separated by fissures into concentric groups of varying size, while the primary starch if present is separated from the secondary starch by a fissure. This was noted in some grains of *N. poeticus ornatus,* but not so frequently nor so distinctly as here. The portion included between the furrows, the hilum and the margin now melts down in a finely granular mass and is then rapidly gelatinized with much swelling of the grain, while the more resistant material at the proximal end and sides nearby is pushed to the margin where it forms a homogeneous-looking, rather refractive band which rapidly grows thinner and more nearly transparent until all the starch therein is gelatinized and only the capsule remains. In the second method the starch immediately surrounding the hilum which usually represents a primary starch formation is divided by cracks into 3, 4, or 5 pieces. The secondary starch surrounding the primary starch assumes a pitted appearance and is divided irregularly by refractive concentric lines into many portions, then as the grain swells and the less resistant material is gelatinized the more resistant material forms a homogeneous-looking refractive band at the margin which is rapidly gelatinized, and the portions of the primary starch are separated somewhat but remain near the center of the grain and are the last part of the grain to be gelatinized. The gelatinized grains are more swollen, have thinner capsules, and are more distorted than in *N. poeticus ornatus.*

Narcissus poeticus herrick (Hybrid).

(Plate 9, fig. 51; Charts D 259 to D 264.)

Histologic Properties.

In *form* the grains are usually simple and isolated, but there are as many compound grains and aggregates as in *N. poeticus poetarum.* The compound grains belong to two types already described under both parents: (1) A small grain adherent to the side or end of a large one and both inclosed in 1 or 2 common secondary lamellæ; (2) 2 small grains inclosed in 4 to 6 or 8 common secondary lamellæ. The aggregates are the same as those of both parents. There are as many simple grains in which a distinction may be made between a primary and a secondary starch formation as in *N. poeticus ornatus,* and fewer than in *N. poeticus poetarum.* The grains are as irregular as those of *N. poeticus,* and the irregularities are due to the same causes. The conspicuous forms are ovoid, lenticular, plano-convex, slender and broad elliptical, and irregularly polygonal. The additional forms are triangular, irregularly pyriform, clam-shell, mussel-shell, and nearly round forms. The grains are not flattened. In form *N. poeticus herrick* shows a closer relationship to *N. poeticus ornatus* than to *N. poeticus poetarum.*

The *hilum* when not fissured is as distinct as in *N. poeticus ornatus* and is more often fissured than in either parent, but not so deeply nor so extensively as in *N. poeticus poetarum,* and very slightly more extensively than in *N. poeticus ornatus.* The fissures have the following forms: (1) A short, straight transverse or longitudinal line; (2) cruciate-, T-, Y-, and X-shaped; (3) a longitudinal fissure, on either side of which is an oblique fis-

sure; (4) an irregularly stellate arrangement of fissures radiating from the hilum; (5) flying-bird shape. The hilum is sometimes centric but commonly is eccentric from 0.4 to 0.28, usually 0.35 of the longitudinal axis. In the character and eccentricity of the hilum *N. poeticus herrick* shows a closer relationship to *N. poeticus ornatus* than to *N. poeticus poetarum.*

The *lamellæ* are as distinct, as coarse, and have the same characteristics and arrangement as in *N. poeticus ornatus.* The number counted on some of the larger grains varies from 8 to 16, usually 10. In the character and arrangement of the lamellæ, *N. poeticus herrick* shows a somewhat closer relationship to *N. poeticus ornatus* than to *N. poeticus poetarum.* There is, however, very little difference to be noted between the parents and the hybrid in this respect.

The *size* of the grains varies from the smaller which are 5 by 5μ, to the larger broad forms which are 38 by 46μ, rarely, 26 by 50μ, in length and breadth. The common sizes are 30 by 22μ, 28 by 30μ, and 24 by 24μ. In size *N. poeticus herrick* shows a somewhat closer relationship to *N. poeticus poetarum* than to *N. poeticus ornatus.*

Polariscopic Properties.

The *figure* is as distinct as in *N. poeticus poetarum,* but is more often well-defined than in that starch, in this respect resembling *N. poeticus ornatus.* The lines intersect one another at angles of widely varying size and are as apt to be bisected and bent as in *N. poeticus poetarum.* The figure, as in *N. poeticus poetarum,* is frequently in the form of a conjugate hyperbola, or of a longitudinal line bisected at both ends.

The *degree of polarization* varies from low to very high (value 47), and there is the same amount of variation in a given aspect of an individual grain as in *N. poeticus poetarum.*

With *selenite* the quadrants are not well defined and are as irregular in shape and as unequal in size as in *N. poeticus poetarum.* The colors, as in *N. poeticus poetarum,* are usually not pure and there are few which have a greenish tinge.

In the character of the figure and the appearance with selenite *N. poeticus herrick* shows a closer relationship to *N. poeticus poetarum,* but in the degree of polarization it shows a closer relationship to *N. poeticus ornatus.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains color a moderate violet tinged with blue (value 45), the same as in *N. poeticus poetarum,* and the color deepens with moderate rapidity, until it is very deep, becoming at the same time more bluish in tint. With 0.125 per cent Lugol's solution, the grains color as lightly as in *N. poeticus poetarum,* and deepen with moderate rapidity until they are deeply colored. After heating in water until the grains are all gelatinized, and then adding a 2 per cent Lugol's solution, the gelatinized *grains* all color a moderate indigo-blue and the *solution* a deep indigo-blue, as in *N. poeticus poetarum.* If the preparation is boiled for 2 minutes and then treated with a 2 per cent Lugol's solution, as in *N. poeticus poetarum* most of the *grain-residues* color a light indigo, and in a few only the *capsule* is stained; the *capsules* color red or reddish violet; and the *solution* a very deep indigo.

Qualitatively and quantitatively the iodine reactions of *N. poeticus herrick* are closer to those of *N. poeticus poetarum* than to those of *N. poeticus ornatus.*

Aniline Reactions.

With *gentian violet* the grains color very lightly at once, and in half an hour they are lightly colored (value 25), less than in either parent, but closer to *N. poeticus ornatus.*

With *safranin* the grains color very lightly at once, and in 30 minutes they are light to moderately colored (value 40), less than in either parent, but closer to *N. poeticus ornatus.*

In the reactions with aniline stains *N. poeticus herrick* shows a closer relationship to *N. poeticus ornatus* than to *N. poeticus poetarum.*

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 69° to 71° C., and of all is 76° to 78° C., mean 77° C.

In the temperature of gelatinization *N. poeticus herrick* is much closer to that of *N. poeticus ornatus* than to *N. poeticus poetarum.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in rare grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 6 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 10 per cent of the total starch in 30 minutes; in about 7 per cent of the grains and 12 per cent of the total starch in 45 minutes; in about 8 per cent of the grains and 14 per cent of the total starch in 60 minutes. (Chart D 259.)

There are fewer grains in which a bubble is formed than in either parent—an accentuation of a characteristic of *N. poeticus poetarum.* The lamellæ are at first indistinct and later become moderately distinct as in both parents. The marginal band of material, which is the first part of the grain to show an increased refractivity, is of the same size and degree of refractivity as in *N. poeticus ornatus.* Gelatinization as in both parents begins at various discrete points on the margin and proceeds according to two methods, both of which are very much like the methods described under *N. poeticus poetarum,* the main differences noted being that there are fewer grains in which gelatinization proceeds inward from the initial points, producing large cup-shaped hollows, and there is somewhat less granule formation than in *N. poeticus poetarum,* but more than in *N. poeticus ornatus.* The gelatinized grains are as much swollen, have a thin capsule, and are as much distorted as in *N. poeticus poetarum.*

In the reaction with chloral hydrate *N. poeticus herrick* shows qualitatively a closer relationship to *N. poeticus poetarum* than to *N. poeticus ornatus.*

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the grains and 5 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 42 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 70 per cent of the total starch in 30 minutes; in about 12 per cent of the grains and 82 per

cent of the total starch in 45 minutes; in about 15 per cent of the grains and 90 per cent of the total starch in 60 minutes. (Chart D 260.) (See footnote, page 516.)

The hilum and lamellæ are both as distinct as in *N. poeticus poetarum*. Gelatinization begins at the hilum and progresses according to two methods which are very similar to those already described under *N. poeticus poetarum*. There are more grains in which the second method occurs than the first, and in both methods the fissures are finer and not so extensive, a marginal band which extends all the way around the margin is often formed, and the striation in this band is not so coarse nor so distinct as in *N. poeticus poetarum* and much less than in *N. poeticus ornatus*. The gelatinized grains are much swollen and have as thin capsules and are as much distorted as in *N. poeticus poetarum*. *N. poeticus herrick* shows qualitatively a much closer relationship to *N. poeticus poetarum* than to *N. poeticus ornatus*.

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 19 per cent of the total starch in 15 minutes; in about 31 per cent of the grains and 69 per cent of the total starch in 30 minutes; in about 40 per cent of the grains and 83 per cent of the total starch in 45 minutes; in about 53 per cent of the grains and 91 per cent of the total starch in 60 minutes. (Chart D 262.)

The hilum and the lamellæ are as distinct as in *N. poeticus poetarum*. Gelatinization begins at the hilum and follows the two methods of procedure described under the parents. The majority of the grains follow closely the method described for a similar number of the grains of *N. poeticus poetarum*, the main points of difference noted being that the material distal to the hilum was not so much fissured and did not gelatinize with so much irregular swelling and distortion. A larger minority than in *N. poeticus poetarum* follows the second method which is very close in most of the grains to that described in *N. poeticus poetarum*, and in a few to that recorded in *N. poeticus ornatus*. The gelatinized grains are as much swollen, have as thin capsules and are as much distorted as in *N. poeticus poetarum*. *N. poeticus herrick* shows qualitatively a closer relationship to *N. poeticus poetarum* than to *N. poeticus ornatus*.

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 30 per cent of the total starch in 5 minutes; in about 26 per cent of the grains and 56 per cent of the total starch in 15 minutes; in about 32 per cent of the grains and 69 per cent of the total starch in 30 minutes; in about 39 per cent of the grains and 78 per cent of the total starch in 45 minutes; in about 43 per cent of the grains and 78 per cent of the total starch in 60 minutes. (Chart D 263.)

The hilum is as distinct as in the parents, and the lamellæ are as distinct as in *N. poeticus ornatus*, and more distinct than in *N. poeticus poetarum*. Gelatinization begins at the hilum as in the parents, and follows two methods of procedure. The majority of the grains are gelatinized very similarly to the method in a like number of the grains of *N. poeticus poetarum*, except that they are not so distinctly fissured and do not swell so irregularly or with so much distortion. A larger minority than in *N. poeticus poetarum* follows the second method which is very close to that described for the majority of the grains of *N. poeticus ornatus*. The gelatinized grains are much swollen and have as thin capsules but are not so much distorted as in *N. poeticus poetarum*, but somewhat more swollen and distorted than in *N. poeticus ornatus*. *N. poeticus herrick* shows qualitatively a closer relationship to *N. poeticus poetarum* than to *N. poeticus ornatus*.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 82 per cent of the entire number of grains and 98 per cent of the total starch in 2 minutes; in more than 99 per cent of the grains and total starch in 5 minutes. (Chart D 264).

The hilum as in the parents is distinct and a small bubble is less often formed there than in *N. poeticus ornatus* but more often than in *N. poeticus poetarum*. The lamellæ are as often distinct as in *N. poeticus poetarum*. Gelatinization begins at the hilum and proceeds according to the two methods which are in general the same for the two parents. In the majority of the grains the method is the same as that described for the majority of the grains of *N. poeticus poetarum*, but there is no apparent separation by fissures of the primary from the secondary starch, or of the secondary into concentric groups of lamellæ as in *N. poeticus poetarum*, and in this respect this starch resembles *N. poeticus ornatus*. In the second method some grains follow that described under *N. poeticus ornatus*, and others that recorded under *N. poeticus poetarum*. The gelatinized grains are as much swollen, have as thin capsules, and are as much distorted as in *N. poeticus poetarum*. *N. poeticus herrick* shows qualitatively a somewhat closer relationship to *N. poeticus poetarum* than to *N. poeticus ornatus*.

Narcissus poeticus dante (Hybrid).

(Plate 9, fig. 54; Charts D 259 to D 264.)

Histologic Properties.

In *form* the grains are usually simple and isolated, and there are fewer compound grains and aggregates than in either parent or in *N. poeticus herrick*. The compound grains belong to the three types described under both parents, the greater number to the type in which 2 small, equal-sized grains are adherent and surrounded by 4 to 8 common secondary lamellæ, and only rare grains to the two other types. The grains are as irregular as in *N. poeticus ornatus* and *N. poeticus herrick*, and the irregularities are due to the same causes as were noted in the parents and *N. poeticus herrick*; and there are more simple grains in which primary and secondary starch formations may be seen than in either *N. poeticus ornatus* or *N. poeticus herrick*, but somewhat fewer than in *N. poeticus poetarum*. The conspicuous forms are ovoid, plano-convex, irregularly polygonal, and nearly round. The additional forms are triangular, pyriform, lenticular, elliptical, and irregularly clam-shell-shaped. The grains are not flattened. In form *N. poeticus dante* shows a somewhat closer relationship to *N. poeticus ornatus* than to *N. poeticus poetarum*. It is more round than *N. poeticus herrick*, and does not show such a close relationship as the other hybrid to *N. poeticus ornatus*.

The *hilum,* if not fissured, is as distinct as in *N. poeticus ornatus;* but it is usually fissured, not so frequently as in *N. poeticus poetarum* or *N. poeticus herrick,* but as extensively and as deeply as in *N. poeticus poetarum.* The fissures have the following forms: (1) Cruciate-, Y-, and T-shaped; (2) a straight line longitudinally or horizontally placed; (3) an irregularly stellate group of fissures. The hilum is sometimes centric, but in the majority of the grains is eccentric from 0.42 to 0.3, usually 0.38, of the longitudinal axis. In the character and eccentricity of the hilum *N. poeticus dante* shows a closer relationship to *N. poeticus poetarum* than to *N. poeticus ornatus.*

N. poeticus dante shows as close a relationship to *N. poeticus poetarum* as does *N. poeticus herrick* to *N. poeticus ornatus.*

The *lamellæ* are in character, arrangement, and distinctness the same as those described under *N. poeticus poetarum.* The number counted on some of the larger grains varies from 8 to 14, usually 10. In the character and arrangement of the lamellæ *N. poeticus dante* shows a closer relationship to *N. poeticus poetarum* than to *N. poeticus ornatus.*

N. poeticus dante shows as close a relationship to *N. poeticus poetarum* as *N. poeticus herrick* does to *N. poeticus ornatus.*

In *size* the grains vary from the smaller which are 5 by 5μ, to the larger broad forms which are 38 by 50μ, in length and breadth. The common sizes are 32 by 32μ and 32 by 40μ.

In size *N. poeticus dante* shows a closer relationship to *N. poeticus poetarum* than to *N. poeticus ornatus.*

N. poeticus dante is larger than *N. herrick* and therefore not so close to *N. poeticus poetarum* in size.

Polariscopic Properties.

The *figure* is usually distinct and is rarely well defined as in *N. poeticus poetarum.* The lines bisect one another at angles of varying size and are apt to be bisected and bent as in *N. poeticus poetarum.* The figure is more often a cross than in *N. poeticus poetarum,* but the other figures described under that starch are also seen.

The *degree of polarization* varies from low to very high (value 47), somewhat lower than in *N. poeticus ornatus,* much higher than in *N. poeticus poetarum,* and the same as in the other hybrid. There is the same amount of variation in the same aspect of a given grain as in *N. poeticus ornatus.*

With *selenite* as in *N. poeticus poetarum* the quadrants are not well defined and are irregular in size and shape. The colors are usually not pure and there are very few grains which show a greenish tinge.

In the character of the figure and the appearances with selenite *N. poeticus dante* shows a closer relationship to *N. poeticus poetarum,* and in the degree of polarization to *N. poeticus ornatus. N. poeticus dante* and *N. poeticus herrick* show the same degree of close relationship to *N. poeticus poetarum* in the polarization, figure, and the reactions with selenite, but to *N. poeticus ornatus* in the degree of polarization.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate violet tinged with blue (value 45), the same as in *N. poeticus poetarum* and the other hybrid, and the color deepens with moderate rapidity until it is very deep, becoming bluer in tint at the same time. With 0.125 per cent Lugol's solution the grains all color a light violet, the same as in *N. poeticus poetarum.* After heating in water until all the grains are completely gelatinized and then adding a 2 per cent Lugol's solution the gelatinized *grains* all color a moderate indigo-blue and the solution a deep indigo-blue as in *N. poeticus poetarum.* If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution most of the *grain-residues* color a light indigo-blue, and only the capsules of some are colored. The *capsules* color a red or a reddish violet, and the *solution* a very deep indigo-blue as in *N. poeticus poetarum.* Qualitatively and quantitatively the iodine reactions of *N. poeticus dante* are closer to those of *N. poeticus poetarum* than to those of *N. poeticus ornatus.* There are no marked differences between the reactions of the two hybrids.

Aniline Reactions.

With *gentian violet* the grains all color lightly at once, and in half an hour they are lightly to moderately colored (value 35), the same as in *N. poeticus poetarum.*

With *safranin* the grains color lightly at once, and in half an hour they are moderately colored (value 50) the same as in *N. poeticus poetarum.*

In the reaction with aniline stains *N. poeticus dante* shows a much closer relationship to *N. poeticus poetarum* than to *N. poeticus ornatus.*

N. poeticus dante stains more than does *N. poeticus herrick* and is closer to *N. poeticus poetarum.*

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 71.2° to 73.1° C., and of all is 74° to 76° C., mean 75° C. The temperature of gelatinization of *N. poeticus herrick* shows a much closer relationship to *N. poeticus ornatus* than to *N. poeticus poetarum.* The temperature of gelatinization of *N. poeticus dante* is lower than that of *N. poeticus herrick* and is practically mid-intermediate between *N. poeticus ornatus* and *N. poeticus poetarum.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 10 per cent of the total starch in 15 minutes; in about 7 per cent of the grains and 12 per cent of the total starch in 30 minutes; in about 11 per cent of the grains and 16 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 259.)

There are a few grains in which a bubble is formed at the hilum as in *N. poeticus herrick,* and fewer than in either parent. The lamellæ are at first indistinct and later become moderately distinct as in both parents and *N. poeticus herrick.* The marginal band of starch, which is the first part to show an increased refractivity, is as narrow and refractive as in *N. poeticus poetarum,* and narrower and less refractive than in either *N. poeticus ornatus* or *N. poeticus herrick.* Gelatinization begins

at various discrete points on the margin and proceeds according to two methods which are even closer to those observed under *N. poeticus poetarum* than those seen in *N. poeticus herrick.* The main point of difference is that there are more grains in which gelatinization proceeds inward from the discrete points on the margin, producing large cup-shaped hollows in the ungelatinized material. The gelatinized grains are much swollen, have a thin capsule, and are as distorted as in *N. poeticus poetarum. N. poeticus dante* shows qualitatively a closer relationship to *N. poeticus poetarum* than to *N. poeticus ornatus.*

In this reaction *N. poeticus dante* shows qualitatively a somewhat closer relationship to *N. poeticus poetarum* than does *N. poeticus herrick.*

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 34 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 67 per cent of the total starch in 30 minutes; in about 10 per cent of the grains and 80 per cent of the total starch in 45 minutes; in about 15 per cent of the grains and 88 per cent of the total starch in 60 minutes. (Chart D 260.)

The hilum is not as distinct as in either parent, and the lamellæ are moderately distinct or indistinct as in *N. poeticus poetarum.* Gelatinization begins at the hilum and progresses according to the two methods described under *N. poeticus poetarum.* There are not so many grains which exhibit the second method described in *N. poeticus herrick,* but more than in *N. poeticus poetarum.* The fissuring is coarser and more extensive than in *N. poeticus poetarum* and the striation is coarser. The other method resembles very closely that described under *N. poeticus ornatus.* The gelatinized grains are much swollen, have as thin walls, and are as much distorted as in *N. poeticus poetarum. N. poeticus dante* shows qualitatively a somewhat closer relationship to *N. poeticus poetarum* than to *N. poeticus ornatus. N. poeticus dante* does not show so close a relationship to *N. poeticus poetarum* as does *N. poeticus herrick.*

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 37 per cent of the total starch in 15 minutes; in about 42 per cent of the grains and 75 per cent of the total starch in 30 minutes; in about 50 per cent of the grains and 88 per cent of the total starch in 45 minutes; in about 55 per cent of the grains and 94 per cent of the total starch in 60 minutes. (Chart D 262.)

The hilum and lamellæ are as distinct as in *N. poeticus poetarum.* Gelatinization begins at the hilum and proceeds according to the two methods described under the parents. In a smaller majority of the grains than in either *N. poeticus poetarum* or *N. poeticus herrick,* the same method is seen as that described for the majority of the grains of *N. poeticus poetarum,* but the starch included between the 2 furrows is less apt to be fissured and more apt to become a nearly homogeneous-looking, hyaline mass as in *N. poeticus ornatus.* In the minority, which are gelatinized according to the second method described under *N. poeticus poetarum* and the first described under *N. poeticus ornatus,* there is a close resemblance in many to the method as described under *N. poeticus ornatus,* and in the rest to that described under *N. poeticus poetarum.* The gelatinized grains are as much swollen, have as thin capsules, and are as distorted as in *N. poeticus poetarum.* In this reaction *N. poeticus dante* shows qualitatively a somewhat closer relationship to *N. poeticus poetarum* than to *N. poeticus ornatus. N. poeticus dante* does not show so close a relationship to *N. poeticus poetarum* as does *N. poeticus herrick.*

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 19 per cent of the total starch in 5 minutes; in about 14 per cent of the grains and 65 per cent of the total starch in 15 minutes; in about 25 per cent of the grains and 72 per cent of the total starch in 30 minutes; in about 38 per cent of the grains and 76 per cent of the total starch in 45 minutes; in about 47 per cent of the grains and 80 per cent of the total starch in 60 minutes. (Chart D 263.)

The hilum is distinct as in the parents and the lamellæ are as distinct as in *N. poeticus poetarum.* Gelatinization begins at the hilum, and proceeds according to the two types described under *N. poeticus poetarum.* There is, however, a smaller majority than in *N. poeticus poetarum* or *N. poeticus herrick* in which the first type is seen, and the grains which are gelatinized in this way are more distinctly granular and more regularly striated, and show less of the irregular pitted appearance and of the irregular criss-cross fissuring than those two starches, but they are not quite so distinctly nor so regularly granular as in *N. poeticus ornatus.* There are fewer which show the second type of gelatinization than in either parent or in *N. poeticus herrick,* and those which show this type resemble those noted in *N. poeticus poetarum.* The gelatinized grains are much swollen and the capsules are as thin and the grains as distorted as in *N. poeticus poetarum.*

In this reaction *N. poeticus dante* shows qualitatively a closer relationship to *N. poeticus poetarum* than to *N. poeticus ornatus.*

N. poeticus dante does not show so close a relationship to *N. poeticus poetarum* as does *N. poeticus herrick,* and in some characteristics shows a closer relationship to *N. poeticus ornatus* than does *N. poeticus herrick* but in some it is much further away than is *N. poeticus herrick.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 75 per cent of the entire number of grains and 95 per cent of the total starch in 2 minutes; in more than 99 per cent of the grains and total starch in 5 minutes. (Chart D 264.)

The hilum, as in the parents, is distinct and a bubble is formed there as frequently as in *N. poeticus ornatus,* and the lamellæ are as often moderately distinct as in *N. poeticus ornatus.* Gelatinization begins at the hilum and progresses according to two methods already described under the parents. The majority of the grains follows in general the method described for a similar number of the grains of *N. poeticus poetarum* and *N. poeticus herrick* and are closer to *N. poeticus poetarum* than to *N. poeticus herrick.* A larger minority, however, than in *N. poeticus poetarum* and *N. poeticus herrick*

follows the second method and in all are very close to that described for the grains of *N. poeticus ornatus,* and differs in various respects from *N. poeticus poetarum.* The gelatinized grains are as much swollen, have as thin capsules, and are as much distorted as in *N. poeticus poetarum.*

In this reaction *N. poeticus dante* shows qualitatively a somewhat closer relationship to *N. poeticus poetarum* than to *N. poeticus ornatus.*

N. poeticus dante is not so close to *N. poeticus poetarum* as is *N. poeticus herrick* and stands more nearly midway between the two parents than does *N. poeticus herrick.*

14. Starches of Narcissus tazetta grand monarque, N. poeticus ornatus, and N. poetaz triumph.

N. poeticus ornatus is described on pp. 515 to 519.

Starch of Narcissus tazetta grand monarque (Seed Parent).

(Plate 10, fig. 55; Charts D 265 to D 286.)

Histologic Properties.

In *form* the grains are usually simple and isolated, but there is a moderate number of aggregates and a somewhat smaller number of compound grains. The compound grains belong to the following three types in the order of the frequency of their occurrence: (1) 2 or 3 moderate-sized grains inclosed in 2 or 3 common secondary lamellæ; (2) a large grain to the distal end, or rarely, to the proximal end of which a small grain has become adherent, and the 2 grains afterward inclosed in 1 or 2 common secondary lamellæ; (3) small grains in which a number of hila are seen in an amorphous-appearing mass, and this surrounded by 1 or 2 common secondary lamellæ. The aggregates are usually doublets, of equal-sized grains, or 1 large and 1 small grain, and triplets and quadruplets in linear or compact arrangement. There are also aggregates of a simple and a compound grain or of 2 or 3 compound grains. A moderate number of the isolated, simple grains may be seen which show distinctly two periods of starch formation, the primary being distinctly separated from the secondary part by a deep furrow. The starches belonging to the two periods show also a difference in their refractivity. The grains are often irregular and the irregularities are due to the following causes: (1) Small rounded or large pointed protuberances from either side or the proximal or the distal end; (2) small, irregular depressions and elevations of the surface and margin; (3) irregular pressure facets on the sides and distal end; (4) a deviation of the long axis of some of the more slender grains. The conspicuous forms are ovoid, pyriform, ellipsoidal, triangular (isosocles or scalene), lenticular dome-shaped, and nearly round. The additional forms are spindle-shaped, reniform, clam-shell-shaped, and club-shaped. Some of the broad forms are flattened, but the rest are not.

The *hilum* when not fissured, is a small, round, or, rarely, lenticular-shaped spot, which is not very distinct. It is usually fissured and the fissures are not very deep nor very extensive, and have the following forms: (1) A single, short, straight, transverse, or longitudinal line; (2) cruciate; (3) a flying-bird figure; (4) rarely, an irregularly stellate mass of fissures. The hilum is sometimes centric, but in the majority of the grains it is eccentric from 0.45 to 0.25, usually 0.35, of the longitudinal axis.

The *lamellæ* are usually not distinct throughout the whole grain, but when they can be seen they appear as moderately fine, continuous rings which have, in general, the form of the outline of the grain. They are more distinct near the hilum than near the margin where they are rarely demonstrable. The entire number can not be counted.

The *size* of the grains varies from the smaller, which are 4 by 4μ, to the larger, which are 38 by 26μ and 28 by 40μ, in length and breadth. The common sizes are 20 by 24μ, and 25 by 18μ.

Comparison of the histologic characteristics of *N. poeticus ornatus* and *N. tazetta grand monarque* shows:

Compound grains and aggregates are not so common as in *N. tazetta grand monarque,* but they belong to the same types described under that grain, except that among the aggregates, triplets and quadruplets either linearly or compactly arranged are not common. There are fewer simple grains which show a well-defined distinction between a primary and a secondary starch formation. The grains are somewhat less irregular than in *N. tazetta grand monarque,* except that deviation of the axis and consequent bending of the grain is not seen and grains are noted in which a regular series of depressions and elevations gives a fluted appearance to the distal surface. These are not present in *N. tazetta grand monarque.* The grains have a varied form as *N. tazetta grand monarque* but there are only slight differences to be noted in the forms. The grains are, rarely, flattened.

The *hilum* when not fissured is not so distinct as in *N. tazetta grand monarque.* It is more often fissured and the fissures are as deep and as extensive as in *N. tazetta grand monarque.* In form they are, however, the same. The range of eccentricity is the same in both starches.

The *lamellæ* are more distinct than in *N. tazetta grand monarque* and are coarse instead of fine continuous rings which are otherwise the same as those of *N. tazetta grand monarque.* There are usually 9 on the larger grains.

In *size* the grains are slightly smaller and there are more broad forms and fewer elongated forms than in *N. tazetta grand monarque.* The common sizes are 22 by 24μ, 24 by 24μ, and 22 by 18μ.

Polariscopic Properties.

The *figure* is usually distinct and moderately well defined. The lines in some grains are fine and in others rather coarse and intersect usually at an acute angle which varies somewhat in size. They are frequently bent or bisected. In some grains the figure is not a cross but has the form of a long line bisected at both ends.

The *degree of polarization* varies from low to very high (value 50). In the majority of the grains the degree of polarization is moderate to moderately high. There is considerable variation in the same aspect of a given grain.

With *selenite* the quadrants are usually not very well defined, and are often irregular in shape and unequal

in size. The colors are usually not pure. There are a few grains which show a greenish tinge.

Comparison of the polariscopic properties of *N. poeticus ornatus* and *N. tazetta grand monarque* shows:

The *figure* is no more distinct or clear-cut than in *N. tazetta grand monarque*. The lines cross at an acute angle of less variable size, and are somewhat less often bent or bisected. The figure sometimes has the form of an hyperbola.

The *degree of polarization* is the same (value 50), with the same amount of variation between the different grains and in the same aspect of a given grain.

With *selenite* the quadrants are less poorly defined and somewhat less irregular in shape. The colors are as often not pure as in *N. tazetta grand monarque*.

Iodine Reactions.

With 0.25 per cent of Lugol's solution, the grains color a light to moderate violet tinged with blue (value 45), which deepens with moderate rapidity until the grains are very deeply colored, becoming at the same time bluer in tint. With 0.125 per cent Lugol's solution the grains color a light violet, which deepens with moderate rapidity until the grains are deeply colored, and at the same time have assumed a blue tint. After heating in water until the grains are gelatinized and then adding 2 per cent Lugol's solution, the gelatinized *grains* color a moderate to moderately deep indigo-blue, and the *solution* a moderately deep indigo-blue. If the preparation is boiled for 2 minutes, and then treated with an excess of 2 per cent of Lugol's solution most of the *grain-residues* are colored a moderate indigo, some a light indigo. The *capsules* are colored reddish violet, and the *solution* a very deep indigo-blue.

Comparison of the iodine reactions of *N. poeticus ornatus* and *N. tazetta grand monarque* shows:

The grains are colored less with 0.25 (value 40) and 0.125 Lugol's solution. After heating in water until the grains are all gelatinized and then adding a 2 per cent Lugol's solution more of the grains are moderately deeply colored and the solution is less deeply colored than in *N. tazetta grand monarque*. After boiling for 2 minutes, more of the grains are moderately colored and the solution less deeply than in *N. tazetta grand monarque*.

Aniline Reactions.

With *gentian violet* the grains all stain very lightly at once, and in half an hour they are light to moderately colored (value 40). There is no variation in depth in the different grains, and there is often some variation in different parts of an individual grain.

With *safranin* the grains all stain very lightly at once, and in half an hour they are moderately colored (value 45), somewhat more than with gentian violet. There is often some variation in different parts of an individual grain.

Comparison of *N. poeticus ornatus* and *N. tazetta grand monarque* shows:

Aniline Reactions.

With *gentian violet* the grains all color somewhat less (value 35) than in *N. tazetta grand monarque*, and there is no variation in color in the individual grains.

With *safranin* the grains all color the same as in *N. tazetta grand monarque* (value 45) and there is no variation in color in the individual grains.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 73° to 75° C., and of all 76° to 77° C., mean 76.5° C.

Comparison of the temperature of gelatinization of *N. poeticus ornatus* and *N. tazetta grand monarque* shows:

Mean 77.5° C. is somewhat higher (1°) than in *N. tazetta grand monarque*.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 16 per cent of the grains and 24 per cent of the total starch in 15 minutes; in about 28 per cent of the grains and 32 per cent of the total starch in 30 minutes; in about 32 per cent of the grains and 36 per cent of the total starch in 45 minutes; in about 34 per cent of the grains and 40 per cent of the total starch in 60 minutes. (Chart D 265.)

The hilum is not distinct in a few grains, and in the great majority a small bubble is formed there, which remains until the reaction is nearly completed. The lamellæ are not visible at first, but later become indistinctly visible in most of the grains. The grains become more refractive in appearance after the reagent is added and the first part to show this increased refractivity is a narrow band of starch at the margin. Gelatinization begins at various discrete points on the distal margin or at the ends of protuberances, wherever they are located. In the less resistant grains gelatinization advances with moderate rapidity from the initial points, with some preliminary fissuring of the ungelatinized starch; when near the hilum the bubble swells, then shrinks and disappears and the hilum swells suddenly, and the proximal starch, which is the most resistant part of the grain is rapidly gelatinized. In the more resistant grains, the margin at the distal end is gelatinized and this is followed by a serial separation and gelatinization of several distal groups of lamellæ. The rest of the grain is then invaded by fissures, and small particles are broken off which gelatinize separately. When gelatinization is near the hilum the bubble swells, then shrinks and finally disappears, and the hilum swells rapidly. The proximal starch, which is the last part of the grain ungelatinized, rapidly assumes a more refractive appearance and is then gelatinized. In the lenticular-shaped grains a third method is noted. A broad refractive fissure is seen in the long axis of the grain, and gelatinization begins at the margin at either end of this and advances smoothly, until the hilum, which is centric, is reached. The hilum swells rapidly and the material immediately surrounding it is quickly gelatinized.

The gelatinized grains are much swollen and have rather thick capsules. They are much distorted and do not retain much resemblance to the form of the untreated grain.

Comparison of *chloral hydrate* reactions of *N. poeticus ornatus* with *N. tazetta grand monarque* shows:

A bubble is not so frequently found at the hilum and the lamellæ are more distinct than in *N. tazetta grand monarque.* The grain becomes more refractive in appearance after the addition of the reagent and the band of material about the margin which is first affected in this way is not so narrow as in *N. tazetta grand monarque.* Gelatinization begins at the ends of protuberances and at various discrete points on the distal margin. It proceeds according to two methods instead of three as in *N. tazetta grand monarque.* The method in the majority of the grains is similar to that described for the more resistant grains of *N. tazetta grand monarque,* except that nearly the entire margin, excluding a small strip at the proximal end, is first gelatinized, and there is no serial separation of the distal lamellæ after the preliminary gelatinization of the margin. The second method is the same as that described for the lenticular-shaped grains of *N. tazetta grand monarque.* The gelatinized grains are more swollen, have thin capsules, and are more distorted than in *N. tazetta grand monarque.*

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 25 per cent of the total starch in 15 minutes; in about 10 per cent of the grains and 75 per cent of the total starch in 30 minutes; in about 40 per cent of the grains and 90 per cent of the total starch in 45 minutes; in about 50 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 266.) (See footnote, page 516.)

The hilum is distinct, and the lamellæ are moderately distinct in all the grains. Gelatinization begins at the hilum and progresses according to two methods. In the first, which is seen in a small majority of the grains, the grain is covered by rather coarse striæ, which radiate from the hilum to the margin, and a sheaf of fissures extends from either end of the hilum nearly to the margin. As the less resistant material of the grain is gelatinized and the grain swells, these fissures increase in size and the more resistant starch on either side is pushed to the margin where it forms a very distinctly striated (at first, indistinctly) lamellated band. The lamellated appearance soon disappears, leaving a coarsely striated band with a spicular inner margin. The fissures, which originally extended nearly to the margin from the hilum, grow wider and more extensive and in many grains finally extend to the capsule which is then dissolved. In other grains they merely grow wider, and thus having divided part of the grains into granules they separate the granules widely. The granules become smaller and more refractive and finally disappear, and the marginal band grows thinner and more nearly transparent and loses its spicular inner border and its striated character and becomes homogeneous in appearance. It remains so for some time, but finally is gelatinized and only the capsule is left. In other grains, the primary material is divided by coarse striæ and forms a striated inner border to the marginal band. This is gelatinized first and the rest of the process is the same as that just described. The second method is seen in a large minority of the grains. Two fissures extend transversely or, rarely, obliquely from the hilum on either side to the margin, and the starch included between them and the hilum and all but a narrow strip at the margin, is divided by very fine fissures into fine granules which are somewhat less fine and more distinctly visible near the hilum. Meanwhile the more resistant material at the proximal end and sides nearby is divided by rather fine radiating striæ, and as the granular distal portion is gelatinized from within outward, and the grain swells, the proximal portion (together with the narrow strip of resistant material left around the rest of the margin) forms a finely striated and indistinctly lamellated band which gradually loses both the lamellated and the striated appearance and becomes homogeneous-looking and is finally gelatinized, the proximal portion being the most resistant.

The gelatinized grains are much swollen, have rather thin capsules, and are not greatly distorted. A moderate number of grains is dissolved before gelatinization is complete.

Comparison of the *chromic acid* reactions of *N. poeticus ornatus* and *N. tazetta grand monarque* shows:

The hilum and lamellæ are somewhat less distinct than in *N. tazetta grand monarque.* Gelatinization follows only one method, which is in general that described for a small majority of the grains of *N. tazetta grand monarque.* The main differences to be noted are—that a sheaf of fissures only extends from the hilum toward the distal margin and not from both sides of the hilum; the granules into which the fissures divide the starch are larger and more distinct; large granules are always formed from the material around the hilum, whether or not a clear division may be seen between primary and secondary starch; the striæ dividing the rest of the grain are not so fine and are more distinct; the marginal band which is formed as the less resistant material swells is divided into two distinct portions, an outer refractive, coarsely striated and lamellated ring, and an inner, less refractive spicular ring with a fringed inner border. The gelatinized grain is more swollen, has thicker capsules, but is no more distorted than in *N. tazetta grand monarque,* and more of the grains are dissolved before gelatinization is complete.

The reaction with *pyrogallic acid* begins in rare grains in 1 minute. Complete gelatinization was not observed in any of the grains, less than 0.5 per cent of the entire number, and 1 per cent of the total starch in 5 minutes; complete gelatinization occurs in but rare grains, less than 0.5 per cent of the entire number, and 20 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 32 per cent of the total starch in 30 minutes; in about 12 per cent of the grains and 47 per cent of the total starch in 45 minutes; in about 38 per cent of the grains and 78 per cent of the total starch in 60 minutes. (Charts D 267 and D 268.)

The hilum is distinct, and the lamellæ are at first moderately distinct in some grains and not distinct in others. Gelatinization begins at the hilum and proceeds according to two methods. In the first, which is seen in a small majority of the grains, the hilum enlarges and the substance of the grain is divided into spicules by coarse striæ radiating from the hilum to the margin. The less resistant starch is gelatinized and swells, and the more resistant starch is pushed to the

margin where it forms a coarsely striated band, the inner border of which is of an irregular spicular character. This is gelatinized from within outward and slowly disappears. In some of these grains in which a primary and a secondary starch formation are present, the primary starch is split into many particles of varying size, which are later sub-divided into granules, and these granules are scattered and line the inner border of the marginal band which is formed of the secondary starch and has already been described. These granules are usually resistant and sometimes persist after the rest of the grain is gelatinized. In the second method, which occurs in a large minority of the grains, 2 furrows extend transversely from the hilum to the margin, and the starch included between them, the hilum, and the margin, becomes more refractive in appearance and then loses its lamellar structure, changing to a mass of fine granules. The proximal material meanwhile is rather finely striated, and as the distal material slowly gelatanizes this in connection with a strip of resistant starch around the rest of the margin forms a striated marginal band which, if the reaction is long continued (as it usually is), is usually cracked in many places. The distal material in the interior of the grain is gelatinized first, then the marginal material, that at the proximal end being the last to go. The gelatinized grains are much swollen, have rather thin capsules, and are not greatly distorted.

Comparison of pyrogallic acid reaction of *N. poeticus ornatus* and *N. tazetta grand monarque* shows:

The hilum is as distinct, but the lamellæ are somewhat less distinct than in *N. tazetta grand monarque*. Gelatinization progresses according to two methods which are in general the same as those described under *N. tazetta grand monarque*. In the first, which occurs in a majority of the grains and which is the same as that which is observed in a small majority of the grains of *N. tazetta grand monarque*, the main points of difference noted are that rather large granules are always formed of the material immediately around the hilum, whether there is a clear division between the primary and the secondary starch or not, and the striation of the rest of the grain is finer and a lamellated appearance persists for some time in the marginal band. In the second type there is no appearance of granulation in the distal material, but it becomes merely a homogeneous-looking, refractive mass which is slowly gelatinized. The gelatinized grains are more swollen and have thicker capsules than in *N. tazetta grand monarque,* but are not so much distorted.

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in but rare grains, less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 8 per cent of the grains and 14 per cent of the total starch in 15 minutes; in about 12 per cent of the grains and 26 per cent of the total starch in 30 minutes ; in about 18 per cent of the grains and 31 per cent of the total starch in 45 minutes; in about 25 per cent of the grains and 42 per cent of the total starch in 60 minutes. (Chart D 269.)

The hilum is distinct and a bubble is not observed to form in it in any grain. The lamellæ are at first moderately distinct in some grains, and are not distinct in others, later they are more prominent in a small majority of the grains. Gelatinization begins at the hilum which swells somewhat, and from this point two methods of procedure are seen. In the less resistant grains, which are in the majority, the grain is divided into spicules by coarse striæ, and these spicules are in turn divided into rows of coarse granules by the separation of the lamellæ from one another. As gelatinization proceeds from the hilum toward the margin, these granules are gelatinized, except those formed from the material just at the margin which are resistant and remain for some time bordered on the inner side by a delicate, nearly transparent, rather feathery mass of starch which probably represents the nearly gelatinized inner material of the grain and which remains apparently unaffected after the marginal starch has been completely gelatinized. In a moderate number of these grains, there is a division into periods of primary and secondary starch formation, and in such grains the primary deposit is split into particles of varying size or number which either speedily become subdivided into granules that are scattered to line the inner border of the marginal band formed from secondary starch, or, rarely, remain clumped in the center of the grain while the secondary starch is gelatinized around them. In any case they are very resistant and often persist after all the rest of the grain is gelatinized. The second method of gelatinization occurs in a large minority of the grains, and consists in the extension from the hilum to the margin of 2 transverse fissures or furrows. The portion included between them and the hilum and the distal margin becomes more refractive and is then divided by fine fissures into a great number of small granules which are not arranged like the lamellæ. The proximal material in the meantime becomes coarsely striated, but shows no distinct lamellæ, and as the grain swells it forms a marginal band at the proximal end and sides nearby, of which the outer border is composed of refractive granules, and is continuous with a similar border of granules around the entire margin. The granular material distal to and at the sides of the hilum is gelatinized first, and then the proximal starch and finally the marginal granular ring.

The gelatinized grains are much swollen and have rather thin capsules, but are not greatly distorted. A number of grains are partially dissolved before gelatinization is complete.

Comparison of the *nitric acid* reactions of *N. poeticus ornatus* and *N. tazetta grand monarque* shows:

The hilum is as distinct and the lamellæ are somewhat less distinct but later are obscured. The grains are gelatinized according to three types as in *N. tazetta grand monarque,* and which differ from those described under this starch in that there is a majority of grains in which coarse particles are formed of the primary starch about the hilum, and these fragments or particles remain larger and are not so much subdivided as in *N. tazetta grand monarque;* and the second type of gelatinization which is seen less often is accompanied by much less fissuration and granulation than in *N. tazetta grand monarque*. The gelatinized grains are more swollen and have thicker capsules but are not so much distorted as those of *N. tazetta grand monarque.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 62 per cent of the entire number of grains and 86 per cent of the total starch in 2 minutes; in about 95 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes; in more than 99 per cent of the grains and total starch in 10 minutes. (Chart D 270.)

The hilum is distinct and a small bubble is formed there in a great majority of the grains. The lamellæ are moderately distinct in most of the grains and indistinct in others. Gelatinization begins at the hilum and progresses according to two methods. In the first, which is seen in a small majority of the grains, the starch immediately surrounding the hilum, which can often be distinguished as a primary starch formation, is divided by many coarse striæ, and the secondary starch becomes more refractive in appearance and apparently loses its lamellar character. The less resistant starch in both primary and secondary starches is gelatinized and the grain swells, the more resistant material of both being pushed to the margin. The secondary deposit forms an outer, homogeneous-looking, refractive band which is lined on the inside by a striated, fringed border of the primary starch which is more resistant than the secondary starch, and which remains for some time after the rest of the grain is completely gelatinized, but which gradually grows thinner and more refractive and is finally also gelatinized. In the second method, which occurs in a large minority of the grains, 2 furrows extend transversely from either side of the hilum to the margin and the material between them and the hilum, and the margin quickly melts down into a granular mass which is then gelatinized with much irregular swelling and considerable distortion of the capsule. The proximal material meanwhile becomes more refractive and is pushed to the proximal margin where it forms a homogeneous-looking refractive band which, after the distal material is gelatinized, becomes thinner and more nearly transparent until it too is gelatinized and only the capsule is left. The gelatinized grains are much swollen, have rather thin capsules and are much distorted.

Comparison of the *sulphuric acid* reactions of *N. poeticus ornatus* and *N. tazetta grand monarque* shows:

A bubble is not so frequently formed at the hilum, and the hilum and lamellæ are not, usually, so distinct as in *N. tazetta grand monarque.* Gelatinization progresses according to two methods, which are, in general, the same as those described under *N. tazetta grand monarque.* In the first, which is described for a small majority of the grains of *N. tazetta grand monarque* and which is seen in a larger number of the grains of *N. poeticus ornatus,* the main differences noted are: that the material immediately surrounding the hilum, which is not always distinguishable as a primary starch formation before the reagent is added, is separated from the rest of the grain by a fissure and is broken into 3 or 4 pieces. The remainder of the substance of the grain forms a homogeneous-looking, refractive, marginal band around the inner border of which the particles of the primary material are first arranged, and then divided into a mass of granules which are soon gelatinized. In the second method which is seen in but few grains there are no essential differences noted between the two starches. The gelatinized grains are not so much swollen, have thicker capsules, and are not quite so much distorted as in *N. tazetta grand monarque.*

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 8 per cent of the entire number of grains and 73 per cent of the total starch in 5 minutes; in about 37 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 57 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 77 per cent of the grains and 97 per cent of the total starch in 45 minutes; in about 83 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 271.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 16 per cent of the total starch in 5 minutes; in about 8 per cent of the grains and 32 per cent of the total starch in 15 minutes; in about 10 per cent of the grains and 38 per cent of the total starch in 30 minutes; in about 14 per cent of the grains and 42 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 46 per cent of the total starch in 60 minutes. (Chart D 272.)

Gelatinization begins with the swollen hilum and proceeds along sharply defined fissures; the margin at the proximal end and sides nearby is the most resistant. The gelatinized grains are swollen but not usually distorted so that they resemble the form of the untreated grain.

Comparison of the *potassium hydroxide* reactions of *N. poeticus ornatus* and *N. tazetta grand monarque* shows:

Gelatinization begins and proceeds about the same as in *N. tazetta grand monarque.* The margin of the larger grains is less resistant than in *N. tazetta grand monarque.* Scattered among these larger grains are some of medium size which are quite resistant; a larger proportion of these are present than in *N. tazetta grand monarque* which causes a smaller disparity between the percentage of the grains and the total starch gelatinized. The gelatinized grains are swollen and not usually distorted as in *N. tazetta grand monarque.*

The reaction with *potassium iodide* begins in 30 seconds. Complete gelatinization occurs in but rare grains, less than 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 17 per cent of the total starch in 15 minutes; in about 14 per cent of the grains and 55 per cent of the total starch in 30 minutes; in about 20 per cent of the grains and 69 per cent of the total starch in 45 minutes; in about 38 per cent of the grains and 75 per cent of the total starch in 60 minutes. (Chart D 273.)

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 8 per cent of the entire number of grains and 39 per cent of the total starch in 5 minutes; in about 31 per cent of the grains and 62 per cent of the total starch in 15 minutes; in about 54 per cent of the grains and 76 per cent

of the total starch in 30 minutes; in about 63 per cent of the grains and 89 per cent of the total starch in 45 minutes; in about 66 per cent of the grains and 94 per cent of the total starch in 60 minutes. (Chart D 274.)

The reaction with *potassium sulphide* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of both the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the total starch in 15 minutes; still complete gelatinization is observed in but rare grains and 1 per cent of the total starch in 30 minutes; in about the same number of grains and 2 per cent of the total starch in 45 minutes; in about the same number of grains and total starch in 60 minutes. (Chart D 275.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 19 per cent of the grains and 43 per cent of the total starch in 15 minutes; in about 25 per cent of the grains and 58 per cent of the total starch in 30 minutes; in about 39 per cent of the grains and 73 per cent of the total starch in 45 minutes; in about 48 per cent of the grains and 78 per cent of the total starch in 60 minutes. (Chart D 276.)

The reaction with *sodium sulphide* begins in about 30 seconds. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 7 per cent of the total starch in 15 minutes; in about 6 per cent of the grains and 28 per cent of the total starch in 30 minutes; in about 12 per cent of the grains and 40 per cent of the total starch in 45 minutes; in about 16 per cent of the grains and 50 per cent of the total starch in 60 minutes. (Chart D 277.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 8 per cent of the entire number of grains and 39 per cent of the total starch in 5 minutes; in about 76 per cent of the grains and 82 per cent of the total starch in 15 minutes; in about 99 per cent of the grains and over 99 per cent of the total starch in 30 minutes. (Chart D 278.)

The reaction with *calcium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 14 per cent of the total starch in 30 minutes; in about 5 per cent of the grains and 39 per cent of the total starch in 45 minutes; in about 11 per cent of the grains and 42 per cent of the total starch in 60 minutes. (Chart D 279.)

The reaction with *uranium nitrate* begins in but rare grains in 1 minute. Complete gelatinization was not observed in any grains and the reaction has begun in but few, and less than 0.5 per cent of the total starch is gelatinized in 5 minutes; complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 15 minutes; in about the same percentage of the grains and 4 per cent of the total starch in 30 minutes; in about 1 per cent of the grains and 5 per cent of the total starch in 45 minutes; in about the same percentage of both the grains and total starch in 60 minutes. (Chart D 280.)

The reaction with *strontium nitrate* begins in rare grains in 1 minute. Complete gelatinization was not observed in any grains and about 1 per cent of the total starch is gelatinized in 5 minutes; complete gelatinization occurs in about 3 per cent of the entire number of grains and 8 per cent of the total starch in 15 minutes; in about 10 per cent of the grains and 33 per cent of the total starch in 30 minutes; in about 14 per cent of the grains and 53 per cent of the total starch in 45 minutes; in about 22 per cent of the grains and 60 per cent of the total starch in 60 minutes. (Chart D 281.)

The reaction with *cobalt nitrate* begins in rare grains in 1 minute. Complete gelatinization was not observed in any of the grains and but slight progress is made in the reaction, less than 0.5 per cent of both the grains and total starch gelatinized in 5 minutes; complete gelatinization is still not observed in any grains and about 1 per cent of the total starch gelatinized in 15 minutes; complete gelatinization occurs in about 0.5 per cent of the grains and 2 per cent of the total starch in 30 minutes; little if any further progress noted in 45 and 60 minutes, respectively. (Chart D 282.)

The reaction with *copper nitrate* begins in a very few grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 4 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 6 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 7 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 9 per cent of the total starch in 60 minutes. (Chart D 283.)

The reaction with *cupric chloride* begins in a few grains in 1 minute. Complete gelatinization was not observed in any of the grains and 0.5 per cent of the total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 30 minutes; in about 2 per cent of the grains and 4 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 5 per cent of the total starch in 60 minutes. (Chart D 284.)

The reaction with *barium chloride* has begun in but few grains by a slight deepening of the fissures in 2 minutes. Complete gelatinization does not occur in any of the grains and the process has begun in but few in 5 minutes; very little if any advance occurs in 15, 30, 45, and 60 minutes, respectively. (Chart D 285.)

The reaction with *mercuric chloride* begins in very rare grains in 2 minutes. Complete gelatinization was not observed in any of the grains and the reaction had begun in but very few in 5 minutes; complete gelatinization was not observed in any of the grains and in only 0.5 per cent of the total starch in 15 minutes; complete gelatinization occurs in rare grains, less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 30 minutes; only rare grains are completely and 3 per cent of the total starch gelatinized in 45 minutes; and about the same amounts of both the grains and total starch in 60 minutes. (Chart D 286.)

NARCISSUS POETAZ TRIUMPH (HYBRID).

(Plate 10, fig. 57; Charts D 265 to D 286.)

HISTOLOGIC PROPERTIES.

In *form* the grains are usually simple and isolated. Compound grains and aggregates are not so frequently seen as in *N. tazetta grand monarque,* but more frequently than in *N. poeticus ornatus.* The compound grains belong to two types, which are seen in both parents: (1) 2 moderate-sized grains inclosed in 2 or 3 common secondary lamellæ; (2) a large grain, to the side or distal end of which a small grain has become adherent, and both later inclosed in 1 or 2 common secondary lamellæ. The aggregates have the same numbers and kinds of grains and arrangement as in *N. tazetta grand monarque.* There are also somewhat fewer simple grains than in *N. tazetta grand monarque* in which a clear differentiation can be made between a primary and a secondary starch formation; but there are more than in *N. poeticus ornatus.* The grains are more irregular in form than in either parent, in which respect they more nearly resemble *N. tazetta grand monarque,* and the irregularities are due to the same causes as in the parents. The conspicuous forms are ovoid, triangular (usually scalene), plano-convex, pyriform, and dome-shaped. The additional forms are reniform, spindle-shaped, lenticular, quadrilateral with rounded angles, and club-shaped. The grains are as often flattened as in *N. tazetta grand monarque,* and more often than in *N. poeticus ornatus.* In form *N. poetaz triumph* shows a somewhat closer relationship to *N. tazetta grand monarque* than to *N. poeticus ornatus.*

The *hilum* when not fissured is as distinct as in *N. poeticus ornatus.* It is more often fissured and the fissures are deeper and more extensive than in either parent, and in this respect the resemblance is somewhat closer to *N. poeticus ornatus.* The fissures have the same arrangement as in both parents. The hilum is sometimes centric, but in the majority of the grains it is eccentric from 0.42 to 0.25, usually 0.35, of the longitudinal axis.

In the character of the hilum *N. poetaz triumph* shows a somewhat closer relationship to *N. poeticus ornatus* than to *N. tazetta grand monarque.* The degree of eccentricity is the same in all three starches.

The *lamellæ* are as often not distinct, and are as fine and have the same general arrangement as far as could be observed as in *N. tazetta grand monarque.* The number on the grains can not be determined. In the character of the lamellæ *N. poetaz triumph* shows a somewhat closer relationship to *N. tazetta grand monarque* than to *N. poeticus ornatus;* but there are no great differences between either parents and hybrid with regard to the lamellæ.

The grains in *size* vary from the smaller which are 4 by 4μ to the larger broad forms which are 34 by 42μ and the larger elongated forms which are 40 by 28μ in length and breadth. The common sizes are 24 by 30μ and 32 by 26μ. In size and proportions the grains show a somewhat closer relationship to *N. tazetta grand monarque* than to *N. poeticus ornatus,* though the common size is larger than in either parent.

POLARISCOPIC PROPERTIES.

The *figure* is moderately distinct and as poorly defined as in *N. poeticus ornatus.* The lines usually cross at an acute angle which is not very variable in size, and they are sometimes bent and bisected as in *N. poeticus ornatus.* The figure has sometimes the form of an hyperbola or a long line bisected at both ends.

The *degree of polarization* varies from low to very high (value 50), the same as in both parents. There is the same amount of variation in the same aspect of a given grain.

With *selenite* the quadrants are as poorly defined and as irregular in shape and as unequal in size as in *N. poeticus ornatus.* The colors are usually not pure as in both parents.

In the character of the figure and in the appearances with selenite, *N. poetaz triumph* shows a somewhat closer relationship to *N. poeticus ornatus* than to *N. tazetta grand monarque.* There is no difference to be noted in the degree of polarization of the three starches.

IODINE REACTIONS.

With 0.25 per cent Lugol's solution, the grains all color a light to moderate violet tinged with blue (value 40), the same as in *N. poeticus ornatus,* and then deepen with moderate rapidity until all the grains are very deeply colored and have assumed more of a bluish tint. With 0.125 per cent Lugol's solution, the grains all color a light violet, the same as in *N. poeticus ornatus,* the color deepens with moderate rapidity until they are deeply colored and have assumed a bluish tinge. After heating in water until all the grains are completely gelatinized and then adding a 2 per cent Lugol's solution the *grains* all color a moderate or moderately deep indigo-blue, and the *solution* colors a moderate indigo-blue as in *N. poeticus ornatus.* If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* color a light to moderate indigo-blue, the *capsules* a red or reddish violet, and the *solution* a very deep indigo as in *N. poeticus ornatus.* Qualitatively and quantitatively the reaction of *N. poetaz triumph* with iodine shows a closer relationship to *N. poeticus ornatus* than with *N. tazetta grand monarque.*

ANILINE REACTIONS.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes they are light to moderately colored (value 32), less than in either parent, but closer to *N. poeticus ornatus.*

With *safranin* the grains all color very lightly at once, and in 30 minutes they are light to moderately colored (value 40), less than in either parent whose values correspond. In the reaction with gentian violet *N. poetaz triumph* shows a closer relationship to *N. poeticus ornatus* than to *N. tazetta grand monarque.* Nothing is shown by the reaction with safranin.

TEMPERATURE REACTIONS.

The temperature of gelatinization of the majority of the grains is 73° to 75° C., and of all is 76° to 77° C., mean 76.5° C.

The temperature of gelatinization of *N. poetaz triumph* is the same as that of *N. tazetta grand monarque.*

EFFECTS OF VARIOUS REAGENTS.

The reaction with *chloral hydrate* begins in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 4 per cent of the total

starch in 5 minutes; in about 22 per cent of the grains and 28 per cent of the total starch in 15 minutes; in about 46 per cent of the grains and 50 per cent of the total starch in 30 minutes; in about 48 per cent of the grains and 53 per cent of the total starch in 45 minutes; in about 52 per cent of the grains and 56 per cent of the total starch in 60 minutes. (Chart D 265.)

In a smaller majority of the grains than in *N. tazetta grand monarque* a small bubble is formed at the hilum and the lamellæ are never more distinct than in that starch. The grains become refractive in appearance after the reagent is added and the first part to show this increased refractivity is a rather narrow band of material about the margin, which is as narrow and refractive as in *N. tazetta grand monarque.* Gelatinization in both parents begins at the ends of protuberances or at various discrete points on the distal margin and progresses according to two methods which are very close to the two described under *N. tazetta grand monarque* for the more resistant and the lenticular-shaped grains. The main points of difference noted, being that in the first method, there are not so many grains in which serial separation and gelatinization of the distal lamellæ take place, and gelatinization proceeds with less fissuring and separation of particles from the ungelatinized material. The second method in the lenticular grains is the same as in both parents. The gelatinized grains are as much swollen, have as thick capsules, and are as much distorted as in *N. tazetta grand monarque. N. poetaz triumph* shows qualitatively a closer relationship to *N. tazetta grand monarque* than to *N. poeticus ornatus.*

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 13 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 75 per cent of the total starch in 15 minutes; in about 45 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 65 per cent of the grains and 97 per cent of the total starch in 45 minutes; in about 88 per cent of the grains and 99 per cent of the total starch in 60 minutes. (Chart D 266.) (See footnote, page 516.)

The hilum and lamellæ are as distinct as in *N. tazetta grand monarque.* Gelatinization begins at the hilum and progresses in general according to the two methods described under *N. tazetta grand monarque.* A small majority, less even than in *N. tazetta grand monarque,* follows the method described for a small majority of the grains of that starch, and the main differences noted are that the material around the hilum is more often divided into granules, and the striæ dividing the unfissured material are coarser—in these two respects showing a resemblance to *N. poeticus ornatus.* In the second method, which is not seen at all in *N. poeticus ornatus,* the only points of difference are that the striæ which divide the material at the proximal end are coarser and the granules into which the distal material is divided are not so fine and are more distinct. The gelatinized grains are as much swollen, have as thick capsules, and are no more distorted than in *N. tazetta grand monarque.*

In the reaction with chromic acid *N. poetaz triumph* shows qualitatively a closer relationship to *N. tazetta grand monarque* than to *N. poeticus ornatus.*

The reaction with *pyrogallic acid* begins in a few grains in 1 minute. Complete gelatinization was not observed in any of the grains and of only 3 per cent of the total starch in 5 minutes; in about 3 per cent of the entire number of grains and 25 per cent of the total starch in 15 minutes; in about 27 per cent of the grains and 75 per cent of the total starch in 30 minutes; in about 41 per cent of the grains and 86 per cent of the total starch in 45 minutes; in about 58 per cent of the grains and 95 per cent of the total starch in 60 minutes. (Chart D 267.)

The hilum is as distinct as in both parents, and the lamellæ are as distinct as in *N. tazetta grand monarque.* Gelatinization begins at the hilum and progresses according to the two methods, which are in general the same in both parents. In the first method, which is seen in a smaller proportion of the grains than in *N. tazetta grand monarque,* the chief difference is that there are more grains in which the material around the hilum is broken up into large particles which are more resistant than the rest of the grain, not so many, however, as in *N. poeticus ornatus.* In the second method which is seen in a large minority of the grains there are no marked differences between the hybrid and *N. tazetta grand monarque.*

The gelatinized grains are as much swollen, have as thin capsules, and are as much distorted as in *N. tazetta grand monarque. N. poetaz triumph* shows qualitatively a somewhat closer relationship to *N. tazetta grand monarque* than to *N. poeticus ornatus.*

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 28 per cent of the grains and 60 per cent of the total starch in 15 minutes; in about 41 per cent of the grains and 74 per cent of the total starch in 30 minutes; in about 54 per cent of the grains and 86 per cent of the total starch in 45 minutes; in about 62 per cent of the grains and 88 per cent of the total starch in 60 minutes. (Chart D 269.)

The hilum is as distinct as in the parents, and the lamellæ are as distinct as in *N. tazetta grand monarque,* and are later obscured only to appear again in some grains as in that starch. Gelatinization begins at the hilum and follows two methods of procedure as in the parents, but they are closer to the methods described under *N. tazetta grand monarque* than those recorded under *N. poeticus ornatus,* except that in the first method in which gelatinization occurred evenly in all directions from the hilum, there are more in which a primary and secondary starch formation may be seen, with the consequent deposit of resistant particles from the primary starch, but there are not so many of these as in *N. poeticus ornatus.* In the second method described in which two furrows or fissures extend transversely or obliquely from the hilum to the margin, there are somewhat fewer granules found, and these are not so fine as in *N. tazetta grand monarque.*

The gelatinized grains are as much swollen and have as thick capsules and are as much distorted as in *N. tazetta grand monarque. N. poetaz triumph* shows qualitatively a somewhat closer relationship to *N. tazetta grand monarque* than to *N. poeticus ornatus.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 87 per cent of the entire number of grains and 98 per cent of the total starch in 2 minutes; in more than 99 per cent of the grains and total starch in 5 minutes. (Chart D 270.)

The hilum and lamellæ are as distinct and a bubble is as frequently formed at the hilum as in *N. poeticus ornatus.* Gelatinization begins at the hilum and progresses according to the two methods described under both parents. The first method, which is noted in an even smaller majority of the grains than in *N. tazetta grand monarque,* is more like that seen in *N. tazetta grand monarque* than in *N. poeticus ornatus;* the only difference noted is that in some grains the primary is separated from the secondary starch by a fissure, and remains unaffected as the secondary starch is gelatinized around it. When this process is complete, it gelatinizes as would an ordinary simple grain. In the second method no differences are noted between the three starches.

The gelatinized grains are as much swollen, have as thin capsules, and are as much distorted as in *N. tazetta grand monarque.* *N. poetaz triumph* shows qualitatively a somewhat closer relationship to *N. tazetta grand monarque* than to *N. poeticus ornatus.*

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 30 per cent of the entire number of grains and 90 per cent of the total starch in 5 minutes; in about 70 per cent of the grains and 98 per cent of the total starch in 15 minutes; in about 86 per cent of the grains and 99 per cent of the total starch in 30 minutes; in about 88 per cent of the grains and in over 99 per cent of the total starch in 45 minutes; in about 93 per cent of the grains and in over 99 per cent of the total starch in 60 minutes. (Chart D 271.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 90 per cent of the total starch in 5 minutes; in about 9 per cent of the grains and 64 per cent of the total starch in 15 minutes; in about 28 per cent of the grains and 75 per cent of the total starch in 30 minutes; in about 47 per cent of the grains and 86 per cent of the total starch in 45 minutes; in about 50 per cent of the grains and 91 per cent of the total starch in 60 minutes. (Chart D 272.)

Gelatinization begins and proceeds about the same as in both parents. The fissures are less clearly defined in many of the grains and the margin is less resistant in the larger ones than in both parents. Scattered among these larger, quickly gelatinizing grains are those of medium size which are less resistant; the proportion of these grains is greater than in either parent, but they are less resistant than in *N. poeticus ornatus.*

The gelatinized grains are swollen as in both parents, but more distortion is present and more do not bear so great a resemblance to the forms of the untreated grains as the parents.

The reaction with *potassium iodide* begins in 30 seconds. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 15 per cent of the grains and 57 per cent of the total starch in 15 minutes; in about 21 per cent of the grains and 75 per cent of the total starch in 30 minutes; in about 31 per cent of the grains and 85 per cent of the total starch in 45 minutes; in about 50 per cent of the grains and 90 per cent of the total starch in 60 minutes. (Chart D 273.)

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 33 per cent of the entire number of grains and 67 per cent of the total starch in 5 minutes; in about 58 per cent of the grains and 83 per cent of the total starch in 15 minutes; in about 71 per cent of the grains and 92 per cent of the total starch in 30 minutes; in about 71 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 83 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 274.)

The reaction with *potassium sulphide* begins in a few grains in 30 seconds. Complete gelatinization was not observed in any grains and occurs in 5 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 9 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 11 per cent of the total starch in 30 minutes; in about 2 per cent of the grains and 13 per cent of the total starch in 45 minutes; in about 2 per cent of the grains (the same as above) and 14 per cent of the total starch in 60 minutes . (Chart D 275.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 14 per cent of the entire number of grains and 31 per cent of the total starch in 5 minutes; in about 34 per cent of the grains and 65 per cent of the total starch in 15 minutes; in about 58 per cent of the grains and 85 per cent of the total starch in 30 minutes; in about 65 per cent of the grains and 90 per cent of the total starch in 45 minutes; in about 72 per cent of the grains and 92 per cent of the total starch in 60 minutes. (Chart D 276.)

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 18 per cent of the total starch in 5 minutes; in about 27 per cent of the grains and 60 per cent of the total starch in 15 minutes; in about 42 per cent of the grains and 75 per cent of the total starch in 30 minutes; in about 44 per cent of the grains and 80 per cent of the total starch in 45 minutes; in about 51 per cent of the grains and 85 per cent of the total starch in 60 minutes. (Chart D 277.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 33 per cent of the entire number of grains and 55 per cent of the total starch in 5 minutes; in over 99 per cent of both grains and total starch in 15 minutes. (Chart D 278.)

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 9 per cent of the total starch in 5 minutes; in about 8 per cent of the grains and 47 per cent of the total starch in 15 minutes; in about 14 per cent of the grains and 56 per cent of the total starch in 30 minutes; in about 23 per cent of the grains and 65 per cent of the total starch in 45 minutes; in about 26 per cent of the grains and 72 per cent of the total starch in 60 minutes. (Chart D 279.)

The reaction with *uranium nitrate* begins in a few grains immediately. Complete gelatinization was not

observed in any grains and 5 per cent of the total starch is gelatinized in 5 minutes; complete gelatinization occurs in about 2 per cent of the entire number of grains and 14 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 20 per cent of the total starch in 30 minutes; in about 6 per cent of the grains and 25 per cent of the total starch in 45 minutes; in about the same percentage of both the grains and total starch in 60 minutes. (Chart D 280.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 8 per cent of the entire number of grains and 25 per cent of the total starch in 5 minutes; in about 28 per cent of the grains and 67 per cent of the total starch in 15 minutes; in about 47 per cent of the grains and 75 per cent of the total starch in 30 minutes; in about 54 per cent of the grains and 81 per cent of the total starch in 45 minutes; in about 62 per cent of the grains and 83 per cent of the total starch in 60 minutes. (Chart D 281.)

The reaction with *cobalt nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in but rare grains, less than 0.5 per cent, and 1 per cent of the total starch in 5 minutes; in about 0.5 per cent of the grains and 3 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 5 per cent of the total starch in 30 minutes; in about 2 per cent of the grains and 6 per cent of the total starch in 45 minutes; little if any further progress in 60 minutes. (Chart D 282.)

The reaction with *copper nitrate* begins in 1 minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 10 per cent of the grains and 25 per cent of the total starch in 15 minutes; in about 16 per cent of the grains and 36 per cent of the total starch in 30 minutes; in about the same percentage of the grains and a slight advance in the total starch in 45 minutes; in about the same percentage of the grains and 38 per cent of the total starch in 60 minutes. (Chart D 283.)

The reaction with *cupric chloride* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the grains and 5 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 10 per cent of the total starch in 15 minutes; in about 7 per cent of the grains and 12 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 16 per cent of the total starch in 45 minutes; in about 8 per cent of the grains and 19 per cent of the total starch in 60 minutes. (Chart D 284.)

The reaction with *barium chloride* begins by a slight gelatinization around the fissures in 2 minutes. Complete gelatinization does not occur in any of the grains and the process has begun in but few grains in 5 minutes; very slight advance in 15 minutes; complete gelatinization occurs in very rare grains and has advanced very little, about 1 per cent of the total starch gelatinized in 30 minutes; very slight if any advance is found in 45 and 60 minutes, respectively. (Chart D 285.)

The reaction with *mercuric chloride* begins in a few grains in 30 seconds. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 10 per cent of the total starch in 30 minutes; in about 4 per cent of the grains and 11 per cent of the total starch in 45 minutes; in about 5 per cent of the grains and 12 per cent of the total starch in 60 minutes. (Chart D 286.)

15. Starches of Narcissus gloria mundi, N. poeticus ornatus, and N. fiery cross.

Starch of *N. poeticus ornatus* is described on pp. 515 to 519.

N. gloria mundi (Seed Parent).

(Plate 10, fig. 58; Charts D 287 to D 292.)

Histologic Properties.

In *form* the grains are usually simple and isolated. There are a few compound grains and a moderate number of small aggregates. The compound grains belong to two types: (1) 2 or 3 small grains adherent and inclosed in 4, 5, or 6 common secondary lamellæ so that they are at the proximal end of a large grain; (2) from 6 or 8 hila in an amorphous appearing mass of starch which is surrounded by 2 or 3 common secondary lamellæ. The aggregates are usually of 2 or 3 small, equal-sized grains linearly arranged, but occasionally consisting of an irregular mass of small grains. There are a few aggregates which consist of a compound and a simple grain. Some of the grains show definite primary and secondary starch-formation. The grains are often irregular in form and the irregularities are due to the following causes: (1) One or more large pointed protuberances from the sides and proximal or distal end; (2) shallow, irregular depressions and elevations in the surface and margin; (3) a bending of the longitudinal or transverse axes of the slender grains; (4) one or more poorly defined pressure facets at the distal end of some grains. The conspicuous forms are lenticular, ovoid, broad, ellipsoidal, irregularly quadrilateral with rounded corners, plano-convex, and triangular with straight or rounded base. The additional forms are nearly round, pyriform, irregularly polygonal, dome-shaped, and club-shell-shaped. The grains are not flattened except some of the larger broad forms, and these, when viewed on edge, appear to have a lenticular form.

The *hilum*, when not fissured, is a small, round, or lenticular-shaped spot which is not very distinct. It is usually fissured and the fissures have the following forms: (1) **T**, **Y**, or cruciate; (2) a small, straight, or curved transverse or longitudinal line; (3) flying-bird shape; (4) and an irregularly stellate group of fissures. The hilum is sometimes centric, but in the great majority of grains is eccentric from 0.42 to 0.27, usually 0.37, of the longitudinal axis.

The *lamellæ* are usually not distinct, but they can be seen in a moderate number of grains. They are rather coarse, continuous rings which all have in general the form of the outline of the grain. In the grains which have primary and secondary starch-formations clearly visible, the lamellæ are seen only in the secondary part. The number of the lamellæ can not be determined as the whole number can not be demonstrated on any one grain.

The grains vary in *size* from the smaller which are 4 by 4μ, to the larger which are 32 by 40μ, in length and

breadth. The common sizes are 22 by 28μ, 24 by 30μ, and 28 by 22μ.

Comparison of the histologic characteristics between *N. poeticus ornatus* and *N. gloria mundi* shows:

Compound grains and aggregates are less often seen than in *N. gloria mundi*. The aggregates have the same appearance and arrangement, and the compound grains belong to three types instead of two. The one not seen in *N. gloria mundi* consists of a large grain to the side or distal end of which a small grain has become adherent and later both are inclosed in 1 to 3 common secondary lamellæ. There are more grains in which a primary and a secondary starch-formation may be clearly seen. The grains are as irregular as those of *N. gloria mundi* and the irregularities are due to the same causes with addition of the following: Regular radiating elevations and depressions of the surface giving a fluted appearance; and small notches or depressions, one on either side of the proximal apex. Ovoid forms are more common and reniform grains are seen which are not present in *N. gloria mundi*. The grains are less broad and rounded and more pointed than in *N. gloria mundi*.

The *hilum* is not very distinct, and is not so frequently nor so extensively fissured as in *N. gloria mundi*, and the most common forms are not the T, Y, and cruciate, but a single longitudinal, transverse, or oblique line which may be somewhat branched. It is, as a rule, somewhat more eccentric than in *N. gloria mundi*.

The *lamellæ* are much more often moderately distinct and somewhat coarser than in *N. gloria mundi;* otherwise the character and arrangement are the same.

In *size* the grains are usually somewhat smaller than in *N. gloria mundi*, the common sizes being 22 by 24μ, 24 by 24μ, and 22 by 18μ, or, on the whole, slightly smaller than in *N. gloria mundi*.

Polariscopic Properties.

The *figure* is usually distinct and moderately well defined though the lines usually become broader and poorly defined near the margin. The lines cross one another at acute angles which vary considerably in size. They are often bent and occasionally bisected and some multiple figures are seen. The figure is not always a cross but may have the form of a conjugate hyperbola or of a long line bisected at both ends.

The *degree of polarization* varies from low to very high, usually moderate or moderately high (value 60). There is commonly considerable variation in a given aspect of a single grain.

With *selenite* the quadrants are usually moderately well defined, unequal in size, and often irregular in shape. In the majority of the grains the colors are not pure and a number have a greenish tinge.

Comparison of the polariscopic properties between *N. poeticus* and *N. gloria mundi* shows:

The *figure* is usually more distinct and better defined, and the lines do not cross at angles of such widely varying size, nor are they so often bent or bisected, and only occasionally does the figure take the form of an hyperbola.

The *degree of polarization* is (value 50) less than in *N. gloria mundi*, and there are more of a moderate degree and less of a moderately high degree than in those grains. There is somewhat less variation in a given aspect of the same grain.

With *selenite* the quadrants are more often well defined and less irregular in shape. The colors are not so often pure and there are fewer grains which have a greenish tinge than in *N. gloria mundi*.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate violet tinged with blue (value 50), which deepens with moderate rapidity until all the grains are very deeply colored. The color has more of a bluish tint as it deepens. With 0.125 per cent Lugol's solution the grains all color a light violet at once and deepen with moderate rapidity until all are deeply colored and have a bluish tint. After heating in water until all the grains are gelatinized and then treated with a 2 per cent Lugol's solution, the gelatinized *grains* all color a moderate or moderately deep indigo-blue, and the *solution* a deep indigo. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution the *grain-residues* all color a light or light to moderate indigo-blue, the *capsules* a red or a reddish violet, and the *solution* a very deep indigo-blue.

Comparison of the iodine reactions between *N. poeticus ornatus* and *N. gloria mundi* shows:

With 0.25 and 0.125 per cent Lugol's solutions the grains color less than in *N. gloria mundi*, and when heated until they all are gelatinized and also boiled for 2 minutes and then treated with a 2 per cent Lugol's solution the reactions are the same as in *N. gloria mundi*.

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes they are light to moderately colored (value 40). The grains are all equally colored and there is no variation in depth in the different parts of the individual grains.

With *safranin* the grains all color, very lightly at once, and in 30 minutes they are moderately colored (value 40) to the same depth as with gentian violet.

Comparison of the aniline reactions between *N. poeticus ornatus* and *N. gloria mundi* shows:

With gentian violet *N. poeticus ornatus* stains very much less (value 30), and with safranin it colors somewhat more (value 45) than *N. gloria mundi*.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 71° to 72.8° C., and of all is 74° to 75° C., mean 74.5° C.

Comparison of the *temperature reactions* between *N. poeticus ornatus* and *N. gloria mundi* shows:

The temperature of gelatinization of *N. poeticus ornatus* is higher by about 3° C. than that of *N. gloria mundi*.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 3 per cent of the grains and 8 per cent of the total starch in 15 minutes; in about 12 per cent of the grains and 27 per cent of the total starch in 30 minutes; in about 19 per cent of the grains and

33 per cent of the total starch in 45 minutes; in about 24 per cent of the grains and 35 per cent of the total starch in 60 minutes. (Chart D 287.)

The hilum is at first indistinct, until a small bubble is formed there in most of the grains. The lamellæ also are indistinct at first in all the grains, but later become moderately distinct in a small majority and remain indistinct in the rest. The grains all become somewhat more refractive, the first portion of the grain to be so affected is a rather narrow band of starch at the margin. Gelatinization begins at discrete points, usually protuberances from the distal margin or sides nearby, and sometimes from the proximal end or sides nearby, and proceeds from these points as if converging toward a common center, hollowing out deep, cup-shaped cavities in the grain as it advances. The substance of the grain becomes brilliantly refractive just in advance of gelatinization and is invaded by rather indistinct fissures which separate particles of varying size. As the process of gelatinization nears the hilum, the bubble usually shrinks and disappears, or swells first, and then shrinks and disappears; and in the majority of the grains a refractive fissure is seen to form and extend from the hilum through the center of the ungelatinized material to the gelatinized portion, splitting the ungelatinized portion into two parts which are separated rather widely and gelatinize independently of one another, one usually becoming gelatinous before the other. In some grains the fissure from the hilum does not form and gelatinization continues from the distal margin until the proximal end is reached, the starch at the proximal end being the most resistant in all the grains.

The gelatinized grains are somewhat swollen and have thin capsules, they are much distorted, and do not retain any resemblance to the form of the untreated grain.

Comparison of the *chloral hydrate* reactions between *N. poeticus ornatus* and *N. gloria mundi* shows:

A bubble is formed in somewhat fewer grains and the lamellæ are more distinct than in *N. gloria mundi.* The grains become more refractive in appearance and the band of material at the margin, which is the first part so affected, is broader than in *N. gloria mundi.* Gelatinization progresses according to two methods. The majority of the grains are gelatinized rather differently from those of *N. gloria mundi,* the main points of difference being that gelatinization extends first around the whole margin which is first partially separated from the rest by a fissure, except a small portion at the proximal end; it then proceeds inward with more fissuring and separation of particles from the ungelatinized material. The second method which occurs in the lenticular-shaped grains is not seen in *N. gloria mundi.* The gelatinized grains are more swollen, have thinner capsules, and are more distorted than in *N. gloria mundi.*

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in less than 1 per cent of the grains and 25 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 65 per cent of the total starch in 30 minutes; in about 21 per cent of the grains and 82 per cent of the total starch in 45 minutes; in about 26 per cent of the grains and 90 per cent of the total starch in 60 minutes. (Chart D 288.) (See footnote, page 516.)

The hilum is distinct and the lamellæ are not very distinct at first, but become more distinct as the reaction progresses. Gelatinization begins at the hilum and progresses according to but one method in all but rare grains. Two furrows or, in many grains, actual fissures proceed from the hilum transversely or slightly obliquely to the margin, and just distal to these fissures and parallel with them a number of irregular fissures (looking like a sheaf of wheat or straw) radiate from the hilum. The rest of the starch included between the original furrows or fissures and the margin becomes finely granular, except a rather narrow portion at the margin, which is striated and has a spicular inner border. The less resistant material begins to gelatinize and the grains to swell. The fissures become wider and the part of the grain which they traverse is divided into rather coarse granules that are quickly gelatinized. The material at the proximal end and sides nearby, which is the most resistant part of the grain, is striated and, as the grain swells, is pushed to the margin where it, with the narrow band of material around the rest of the margin, forms a marginal band that is gelatinized more rapidly at the distal end and remains at the proximal end for a long time after the rest of the grain is gelatinized.

The gelatinized grains are much swollen, have rather thin capsules, and are somewhat but not greatly distorted. The capsule in a number of the grains is dissolved at one point before gelatinization is complete, the contents flow out gradually and are dissolved, leaving only a portion of the capsule which is slowly dissolved.

Comparison of the *chromic acid* reactions between *N. poeticus ornatus* and *N. gloria mundi* shows:

The hilum and lamellæ are both more distinct. Gelatinization progresses according to two types, neither of which is seen in *N. gloria mundi.* In the majority of the grains the material immediately surrounding the hilum is divided by fissures into large granules, and longitudinal fissures extend to the distal margin from the hilum. The rest of the material of the grain is divided by coarse striæ. The less resistant starch is gelatinized especially between the hilum and the distal end, the more resistant material forms a marginal band consisting of two layers, an outer striated and lamellated, and an inner spicular one. The interior of the grain meanwhile is filled with rather coarser granules which gelatinize more rapidly than the marginal band. The marginal band is gelatinized more rapidly at the distal end than elsewhere, and finally only the capsule is left. The second method is very much like the first, except that the granules are formed from the primary starch and are very resistant, and there is only one part to the band at the margin, and this is striated and lamellated. The gelatinized grains are not so much swollen, have thicker capsules, and are less distorted than in *N. gloria mundi.* Fewer grains are dissolved before gelatinization is complete than in *N. gloria mundi.*

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 18 per cent of the total starch in 15 minutes; in about 17 per cent of the grains and 65 per cent of the

total starch in 30 minutes; in about 30 per cent of the grains and 78 per cent of the total starch in 45 minutes; in about 48 per cent of the grains and 91 per cent of the total starch in 60 minutes. (Charts D 289 and D 290.)

The hilum is distinct and a bubble is never formed there. The lamellæ are moderately distinct in many grains and not distinct in others. Gelatinization begins at the hilum and progresses according to but one method. Two furrows or actual fissures extend horizontally or with varying degrees of obliquity from the hilum nearly to the margin, and the starch included between these furrows, the hilum, and the margin is divided first by rather coarse striæ and then by fissures, and finally all but a narrow band of material at the margin loses its original structural appearance and becomes a mass of fine granules, which gelatinize slowly from the hilum toward the margin. This is accompanied by some swelling of the grain. The substance at the proximal end and sides, which is the most resistant part of the grain, becomes rather coarsely striated and as the grain swells is pushed to the margin where it, in connection with the narrow band of starch around the rest of the margin, forms a continuous marginal band which gelatinizes very slowly and which if not gelatinized after it has been treated from half to 1 hour by the reagent becomes cracked in many places. The gelatinized grains are much swollen, have rather thick capsules, and are not much distorted.

Comparison of the *pyrogallic-acid* reactions between *N. poeticus ornatus* and *N. gloria mundi* shows:

The hilum and lamellæ are somewhat more distinct. Gelatinization progresses according to two methods, of which the one seen in the great majority of the grains is not seen in any of the grains of *N. gloria mundi*. The starch immediately surrounding the hilum is split into a great number of rather coarse granules, and the rest of the material of the grain is divided by very fine striæ. The less resistant starch is gelatinized and the grain swells slowly, pushing the more resistant material to the margin, where it forms a finely striated and lamellated band around the inner border of which are arranged the granules formed from the deposit nearest the hilum. These granules are very resistant and though they slowly grow smaller and more refractive they remain for some time after the rest of the grain is gelatinized. The marginal band is seen to consist of two layers, an inner spicular and an outer striated and lamellated portion. The inner portion is gelatinized first and then, slowly, the outer portion, which after the reagent has been acting for half to 1 hour is cracked in various places. In a minority of the grains the same method of gelatinization occurs as in *N. gloria mundi,* except that there are no granules formed in the starch distal to the hilum and in the furrows from the hilum, and the striæ at the proximal end are finer. The gelatinized grains are as much swollen, have the same thickness of capsules, and are as much distorted as in *N. gloria mundi.*

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 8 per cent of the total starch in 5 minutes; in about 10 per cent of the grains and 23 per cent of the total starch in 15 minutes; in about 14 per cent of the grains and 47 per cent of the total starch in 45 minutes; in about 19 per cent of the grains and 55 per cent of the total starch in 45 minutes; in about 33 per cent of the grains and 61 per cent of the total starch in 60 minutes. (Chart D 291.)

The hilum is distinct and no bubble is observed to form there. If fissures already exist there, they become wider and more extensive. The lamellæ are distinct and evidences of a lamellar structure persist for a long time after the grain has been, apparently, completely gelatinized. Gelatinization begins at the hilum and in all but rare grains follows one method of procedure. Two fissures or furrows extend transversely or with varying degrees of obliquity from the hilum nearly to the margin, the starch just around the hilum is divided into an irregular mass of large granules and the material comprehended between them and the hilum and the distal margin, which comprises the greater part of the grain, becomes more refractive in appearance, and then is divided by rather coarse striæ into granules which are arranged in rows corresponding to the arrangement of the lamellæ. These are gelatinized from the hilum outward to the margin, and the 3 marginal rows, while losing their granular appearance, retain it for a long time after gelatinization is apparently complete. The material at the proximal end and sides nearby, which is more resistant, has in the meantime become coarsely striated, and as the grain swells this material forms a striated and lamellated band which becomes first granular, and then loses this appearance, and retains merely the suggestion of a lamellar arrangement, as in the other parts of the margin of the grain. This is all lost, however, when the grain is completely gelatinized.

The gelatinized grains are much swollen and have rather thin capsules, but are not much distorted and retain some resemblance to the form of the untreated grain.

Comparison of the *nitric-acid* reactions between *N. poeticus ornatus* and *N. gloria mundi* shows:

The hilum and lamellæ are somewhat more distinct than in *N. gloria mundi.* Gelatinization begins at the hilum and in the great majority of the grains does not follow the same type of procedure as is noted in practically all the grains of *N. gloria mundi.* The hilum swells somewhat and in many of the grains the material immediately surrounding the hilum, which probably represents a primary starch formation, is split up into particles of varying size and shape, and the material surrounding it, which represents a secondary starch formation, becomes striated and as the grain swells forms a striated, non-lamellated marginal band. The particles of primary starch are very resistant and persist in some grains when the rest of the starch has been gelatinized. In a minority of the grains the same method of gelatinization occurs as in *N. gloria mundi,* except that the granules formed are finer and there is more fissuring at the margin, but less in the inner part of the grain.

The gelatinized grains are as swollen and do not have thin capsules, and are as distorted as in *N. gloria mundi.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 88 per cent of the entire number of grains and 99 per cent of the total starch in 2 minutes; in more than 99 per cent of the grains and total starch in 5 minutes. (Chart D 292.)

The hilum is moderately distinct and no bubble is observed there. The lamellæ are not distinct, but can be seen in many grains. Gelatinization begins at the hilum and progresses according to but one method in all but rare grains. Two furrows or actual fissures proceed transversely, rarely obliquely, from either side of the hilum nearly to the margin and become wider and more branched as gelatinization and swelling progress. The starch included between them and the hilum and the margin, becomes finely granular, except a narrow band of material at the margin. The finely granular material gelatinizes with much irregular swelling and distortion of the capsule. The proximal deposit, meanwhile, is pushed to the margin, where it forms a homogeneous-looking band which is continuous with the narrow band of starch around the rest of the margin. The marginal material gelatinizes rather slowly, especially that at the proximal end which often persists for a long time after the rest of the grain is gelatinized.

The gelatinized grains are much swollen, have rather thick capsules, and are somewhat distorted; they do not retain any resemblance to the form of the untreated grain.

Comparison of the *sulphuric-acid* reactions between *N. poeticus ornatus* and *N. gloria mundi* shows:

The hilum is more distinct than in *N. gloria mundi* and a bubble is sometimes formed there. The lamellæ are always visible and are more distinct. Gelatinization progresses according to two methods. That noted in the majority of the grains is seen in only rare grains in *N. gloria mundi.* The starch immediately surrounding the hilum is split into 3 or 4 pieces, and the bubble if present swells, then shrinks, and finally disappears. The less resistant material gelatinizes and the remaining substance of the grain is pushed to the margin, where it forms a homogeneous-looking refractive band, and the 3 or 4 particles formed from the material surrounding the hilum are converted into a mass of fine granules which are soon gelatinized. The marginal band becomes slowly thinner and more nearly transparent until this starch also is gelatinized and only the capsule is left. In the second method, which resembles that described under *N. gloria mundi,* the main differences noted were: the persistence of a lamellar arrangement in the granules formed from the material distal to the hilum and the 2 furrows extending from the hilum to the margin, and the greater refractivity of the starch which is pushed to the margin.

The gelatinized grains are more swollen, have capsules of the same thickness, and are more distorted than in *N. gloria mundi.*

Narcissus fiery cross (Hybrid).

(Plate 10, fig. 60; Charts D 287 to D 292.)

Histologic Properties.

In *form* the grains are usually simple and isolated, but there are a few aggregates and some compound grains, more than in *N. poeticus ornatus* but less than in *N. gloria mundi.* The compound grains belong to the two types described under *N. gloria mundi.* There are as many grains as in *N. poeticus ornatus* in which a clear distinction may be seen between a primary and a secondary starch formation. The grains are as irregular in form, and the irregularities are due to the same causes as in *N. gloria mundi.* The conspicuous forms are, ovoid, plano-convex, dome-shaped, and triangular. The additional forms are lenticular, reniform, nearly round, and pyriform. The grains are somewhat rounded in form as in *N. gloria mundi,* and not so often pointed as in *N. poeticus ornatus.*

In form *N. fiery cross* shows a somewhat closer relationship to *N. gloria mundi* than to *N. poeticus ornatus.*

The *hilum* when it is not fissured is as distinct as in *N. gloria mundi,* but it is usually fissured, not quite so extensively as in *N. gloria mundi,* but more than in *N. poeticus ornatus;* the forms most frequently noted are also like those most frequently seen in *N. gloria mundi.* The forms of the fissures are: (1) T, Y, or cruciate shapes; (2) a short straight or curved line, placed transversely or longitudinally; (3) a flying-bird figure; (4) an irregularly stellate group of fissures. The hilum is sometimes centric, but in the great majority of the grains it is eccentric from 0.4 to 0.21, usually 0.33, of the longitudinal axis.

In the character of the hilum *N. fiery cross* shows a closer relationship to *N. gloria mundi,* but in the degree of eccentricity closer to *N. poeticus ornatus.*

The *lamellæ,* as in *N. gloria mundi,* usually can not be seen, and in the grains in which some can be demonstrated they have the same character and arrangement as in *N. gloria mundi.* The number can not be determined. In the character and arrangement of the lamellæ *N. fiery cross* shows a somewhat closer relationship to *N. gloria mundi* than to *N. poeticus ornatus.*

In *size* the grains vary from the smaller which are 4 by 4μ, to the larger which are 26 by 40μ, and 34 by 40μ, in length and breadth. The common sizes are 26 by 30μ, 24 by 28μ, and 24 by 24μ. In size *N. fiery cross* shows a somewhat closer relationship to *N. gloria mundi* than to *N. poeticus ornatus.*

Polariscopic Properties.

The *figure,* as in *N. poeticus ornatus,* is distinct and is usually not well defined, and the lines show the same amount of increase in size near the margin. The lines cross at nearly the same angle in all the grains as in *N. poeticus ornatus,* but are more often bent and bisected than in those grains, though not quite so often as in *N. gloria mundi.* The figure is sometimes hyperbolic and sometimes a long line bisected at both ends, as in *N. gloria mundi.*

The *degree of polarization* varies from low to very high (value 50), the same as in *N. poeticus ornatus,* and there is the same amount of variation in a given aspect of the same grain as in *N. poeticus ornatus.*

With *selenite* the quadrants, as in *N. poeticus ornatus,* are usually not well defined, and are unequal in size and somewhat irregular in shape. The colors are usually not pure, and there is the same number with a greenish tinge as in *N. poeticus ornatus.*

In the degree of polarization, the character of the figure and the appearances with selenite *N. fiery cross* shows a closer relationship to *N. poeticus ornatus* than to *N. gloria mundi.*

Iodine Reactions.

With 0.25 per cent Lugol's solution, the grains all color a moderate violet tinged with blue (value 60), the

same as in *N. gloria mundi,* and the color deepens with moderate rapidity until the grains are very deeply colored with a much bluer tint. With 0.125 per cent Lugol's solution, the grains all color a light violet, the same as in *N. gloria mundi,* and the color deepens with moderate rapidity until they are deeply colored. If the grains are heated in water until they are completely gelatinized and then treated with a 2 per cent Lugol's solution the gelatinized *grains* color a moderate or a moderately deep indigo-blue and the *solution* a deep indigo-blue as in both parents. If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution the *grain-residues* all color a light or a light moderate indigo; the *capsules* a red or a reddish violet, and the *solution* a very deep indigo, as in both parents.

Quantitatively the reaction with iodine is the same as in *N. gloria mundi;* qualitatively there are no noticeable differences between the hybrid and the parents.

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in half an hour they are light to moderately colored (value 35), midway between *N. gloria mundi* and *N. poeticus ornatus.*

With *safranin* the grains all color very lightly at once, and in 30 minutes they are all light to moderately colored (value 40), the same as in *N. gloria mundi.*

In the reaction with aniline stains *N. fiery cross* shows with safranin a closer relationship to *N. gloria mundi* than to *N. poeticus ornatus.* With gentian violet it is midway between the two parents.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 71° to 72° C., and of all is 73.5° to 75.5° C., mean 74° C.

The temperature of gelatinization of *N. fiery cross* is closer to that of *N. gloria mundi* (mean 74.5°) than to that of *N. poeticus ornatus* (mean 77.5° C.).

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in a few grains in 2 minutes. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 1 per cent of the grains and 3 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 5 per cent of the total starch in 30 minutes; in about 5 per cent of the grains and 9 per cent of the total starch in 45 minutes; in about 7 per cent of the grains and 13 per cent of the total starch in 60 minutes. (Chart D 287.)

The hilum in distinctness and in the size of the bubbles formed is the same as in *N. gloria mundi,* but the latter appear in more grains than in *N. gloria mundi,* and in many more than in *N. poeticus ornatus.* The lamellæ, as in the parents, are at first indistinct, but later are as distinct as in *N. gloria mundi.* The grains become more refractive, the first part of the grain to show this change is a rather narrow marginal band, which is as narrow and as refractive as in *N. gloria mundi.* Gelatinizaton begins usually at one or two points at the distal margin, rarely at so many different points as in either parent. The progress of gelatinization is very similar to that described under *N. gloria mundi,* only it is smoother, more even in all parts of the grain, and accompanied by less fissuring than in that starch—accentuations of characteristics of *N. gloria mundi.*

The gelatinized grains are much swollen, as in the parents, and have as thin capsules and are as much distorted as in *N. gloria mundi.*

In this reaction *N. fiery cross* shows qualitatively a much closer relationship to *N. gloria mundi* than to *N. poeticus ornatus.*

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 12 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 60 per cent of the total starch in 30 minutes; in about 25 per cent of the grains and 85 per cent of the total starch in 45 minutes; in about 65 per cent of the grains and 95 per cent of the total starch in 60 minutes. (Chart D 288.) (See footnote, page 516.)

The hilum is as distinct as in *N. gloria mundi,* but not so distinct as in *N. poeticus ornatus,* and the lamellæ are never so distinct as in either parent. Gelatinization begins at the hilum and in a great majority of the grains progresses according to the method described under *N. gloria mundi,* the process being very nearly the same, except that there is more extensive and deeper fissuring of the part of the grain which is included between the 2 transverse furrows or fissures which are projected from the side of the hilum; and the striæ seen in the proximal deposit are coarser and more distinct. A rather small minority follows the method described for the majority of the grains of *N. poeticus ornatus.* The gelatinized grains are much swollen, have as thin capsules, and are no more distorted than in *N. gloria mundi.* In this reaction *N. fiery cross* shows qualitatively a much closer relationship to *N. gloria mundi* than to *N. poeticus ornatus.*

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 23 per cent of the total starch in 15 minutes; in about 28 per cent of the grains and 70 per cent of the total starch in 30 minutes; in about 43 per cent of the grains and 86 per cent of the total starch in 45 minutes; in about 54 per cent of the grains and 92 per cent of the total starch in 60 minutes. (Chart D 289.)

The hilum and lamellæ are as distinct as in *N. gloria mundi.* Gelatinization begins at the hilum and proceeds according to two methods. In the great majority of the grains the method is that described for all the grains of *N. gloria mundi,* and with certain modifications for a minority of the grains of *N. poeticus ornatus.* In a small minority it is the same as that described for a majority of the grains of *N. poeticus ornatus,* except that the striæ which divide the grains are not so fine and the lamellated appearance in the marginal band is more persistent.

The gelatinized grains are as much swollen, have as thick capsules, and are as much distorted as in the parents.

In this reaction *N. fiery cross* shows qualitatively a closer relationship to *N. gloria mundi* than to *N. poeticus ornatus.*

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 12 per cent of the total starch in 15 minutes; in about 13 per cent of the grains and 30 per cent of the total starch in 30 minutes; in about 23 per cent of the grains and 54 per cent of the total starch in 45 minutes; in about 27 per cent of the grains and 60 per cent of the total starch in 60 minutes. (Chart D 291.)

The hilum and lamellæ are as distinct as in *N. gloria mundi.* Gelatinization begins at the hilum as in the parents. In most of the grains the method of procedure is that described under *N. gloria mundi;* but in a moderate number it is the same as that in the majority of the grains of *N. poeticus ornatus,* except that the striæ are not so coarse and the lamellar appearance of the marginal band remains for a long time as in *N. gloria mundi.*

The gelatinized grains are much swollen and have as thin capsules and are as distorted as in *N. gloria mundi.*

In this reaction *N. fiery cross* shows qualitatively a closer relationship to *N. gloria mundi* than to *N. poeticus ornatus.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 75 per cent of the entire number of grains and 97 per cent of the total starch in 2 minutes; in about 98 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 292.)

The hilum and lamellæ are as distinct and a bubble is seen at the hilum as frequently as in *N. poeticus ornatus.* Gelatinization begins at the hilum and progresses according to the two methods, both of which have been described under *N. poeticus ornatus* and one only under *N. gloria mundi.* The great majority, however, follow very closely the one described under *N. gloria mundi,* which is also seen with some minor differences in a minority of the grains of *N. poeticus ornatus.* A rather small minority follows the method described for the majority of the grains of *N. poeticus ornatus.* The gelatinized grains are as much swollen, have as thick capsules, and are as distorted as in *N. gloria mundi.* In this reaction *N. fiery cross* shows qualitatively a closer relationship to *N. gloria mundi* than to *N. poeticus ornatus.*

16. Starches of Narcissus telamonius plenus, N. poeticus ornatus, and N. doubloon.

Starch of *N. poeticus ornatus* is described on pages 515 to 519.

N. telamonius plenus (Seed Parent).

(Plate 11, fig. 61; Charts D 293 to D 298.)

Histologic Properties.

In *form* the grains are usually simple and isolated, but there are a moderate number of aggregates and a somewhat smaller number of compound grains. The compound grains belong to the following three types in their order of frequency of occurrence: (1) 8 or 9 hila in an amorphous-looking mass of starch which is surrounded by 1 or 2 common secondary lamellæ; (2) a doublet in which a small grain has become adherent to the side or distal end of a large grain, both having been inclosed by 2 or 3 common secondary lamellæ; (3) 2 small equal-sized grains which have become adherent and later surrounded by 7 or 8 common secondary lamellæ. The aggregates consist of 2 or 3 grains which may be of equal or unequal size and linearly arranged. There is a great number of simple grains in which a clear division may be seen between the primary deposit and secondary layers of starch. The grains are usually regular in form, and any irregularities which occur are due to the following causes: (1) A few small or large depressions and elevations in the surface and margin; (2) a greater development of one side or of one part of the distal end than the rest; (3) 1 or 2 rather small, pointed or rounded protuberances from the sides or either end. The conspicuous forms are ovoid, elliptical, nearly round, and triangular with rounded base and angles. The additional forms are plano-convex, lenticular, irregularly polygonal, pyriform, and dome-shaped. The grains are not flattened.

The *hilum,* when not fissured, is usually a distinct round or, rarely, lenticular spot. It is usually fissured, but not deeply nor extensively, and the fissures have the following form: (1) A single short, straight, or rarely curved transverse, oblique, or, rarely, longitudinal line which is sometimes branched; (2) a small Y, T, or cruciate figure; (3) a flying-bird figure; (4) an irregularly stellate mass of fissures. The hilum is sometimes centric, but in the great majority of the grains it is eccentric from 0.46 to 0.23, usually 0.33, of the longitudinal axis.

The *lamellæ* are moderately distinct, rather coarse, continuous rings which all follow the form of the outline of the grain. In those grains in which there are primary and secondary starch formations, the lamellæ are more distinct in the secondary than in the primary part of the grain. The number counted on the larger grains varies from 6 to 12, usually 10.

In *size* the grains vary from the smaller which are 4 by 4μ, to the larger which are 34 by 44μ and 28 by 44μ, in length and breadth. The common sizes are 26 by 22μ, 26 by 26μ, and 26 by 28μ.

Comparison of the *histologic characteristics* between *N. poeticus ornatus* and *N. telamonius plenus* shows:

There are not so many aggregates, but the same number of compound grains which belong to the three types described in *N. telamonius plenus;* but those belonging to the second and third types described under that starch are more numerous than those described under the first type. There are fewer grains in which a primary and a secondary starch formation may be observed. The grains are irregular in form, and the irregularities are due to the first and third causes enumerated in *N. telamonius plenus* and also to: (1) poorly defined pressure facets; (2) more or less regular, radiating elevations and depressions giving a fluted appearance; (3) to 2 notches on either side of the proximal apex. The forms of the grains are much the same in the two starches.

The hilum is not so distinct, but more often and more deeply and extensively fissured, and the fissures have the same forms and the same order of frequency of occurrence. The degree of eccentricity is also very nearly the same, but is somewhat more in *N. telamonius plenus.*

The *lamellæ* are not so distinct nor so coarse and do not always follow so closely the form of the outline of the grain.

In *size* those of *N. poeticus ornatus* are slightly smaller than those of *N. telamonius plenus.*

POLARISCOPIC PROPERTIES.

The *figure* is usually distinct and moderately well defined. The lines intersect at a right angle or an acute angle, are rarely bent, and never observed to be bisected. There are sometimes 5 or 6 lines instead of 4. Occasionally the figure is not a cross, but has the form of a conjugate hyperbola.

The *degree of polarization* varies from low to very high (value 45), most of the grains being moderate and very few high or very high. There is rarely a variation in a given aspect of a single grain.

With *selenite* the quadrants are usually clear-cut, and are unequal in size but regular in shape. The colors are usually not pure and few show a greenish tinge.

Comparison of the *polariscopic properties* between *N. poeticus ornatus* and *N. telamonius plenus* shows:

The *figure* is not so distinct nor so well defined. The lines usually cross at an acute angle and are more often bent, and sometimes are bisected. The figure is more often a conjugate hyperbola or a long line bisected at both ends.

The *degree of polarization* is higher than in *N. telamonius plenus* (value 50), as there are proportionately more grains with a high to a very high degree of polarization. There is more often a variation in the degree of polarization of the different parts of a given aspect of the same grain.

With *selenite* the quadrants are not so well defined and are more irregular in form. The colors are more often pure and there are more grains which show a greenish tinge.

IODINE REACTIONS.

With 0.25 per cent Lugol's solution the grains all color at once a moderate violet tinged with blue (value 45), and the color deepens with moderate rapidity until it is very deep, the bluish tinge increasing as the color deepens. With 0.125 per cent Lugol's solution the grains all color a light violet, which deepens with moderate rapidity, becoming bluish in tint, until they are deeply colored. After heating in water until all the grains are gelatinized and then adding a 2 per cent Lugol's solution, the gelatinized *grains* all color a moderate indigo-blue and the *solution* a deep indigo. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution most of the *grain-residues* color a light indigo, but in some only the *capsule* is colored—the capsule a reddish violet and the *solution* a very deep indigo-blue.

Comparison of the *iodine reactions* between *N. poeticus ornatus* and *N. telamonius plenus* shows:

With 0.25 and 0.125 per cent Lugol's solution the grains color less than in *N. telamonius plenus.* After heating in water and boiling the gelatinized grains, the grain-residues are more deeply colored and the solution less deeply colored than in *N. telamonius plenus.*

ANILINE REACTIONS.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes they are light to moderately colored (value 40). The grains are all colored to the same depth and there is no variation of different parts of the individual grain.

With *safranin* the grains all color very lightly at once, and in 30 minutes they are moderately colored (value 50), more than with gentian violet. The grains are all colored to the same depth, and there is no variation of different parts of the individual grains.

Comparison of the *aniline reactions* between *N. poeticus ornatus* and *N. telamonius plenus* shows:

With gentian violet the grains are colored much less (value 30) and with safranin they are colored less but not so much less as with gentian violet (value 45).

TEMPERATURE REACTIONS.

The temperature of gelatinization of the majority of the grains is 70° to 72° C., and of all is 73° to 75° C., mean 74° C.

Comparison of the *temperature reactions* between *N. poeticus ornatus* and *N. telamonius plenus* shows:

The temperature of gelatinization of *N. poeticus ornatus* is higher—77° to 78° C., mean 77.5° C.

EFFECTS OF VARIOUS REAGENTS.

The reaction with *chloral hydrate* begins in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 9 per cent of the grains and 11 per cent of the total starch in 15 minutes; in about 18 per cent of the grains and 20 per cent of the total starch in 30 minutes; in about 20 per cent of the grains and 22 per cent of the total starch in 45 minutes; in about 22 per cent of the grains and 24 per cent of the total starch in 60 minutes. (Chart D 293.)

The hilum is moderately distinct in the small number of grains in which a bubble is not formed. In a large majority a small bubble, and in a few rare grains a large bubble, is soon formed at the hilum, and remain there unchanged until the reaction is nearly at an end. The lamellæ are visible in a moderate number of grains, but are not very distinct. The grains become somewhat more refractive after the addition of the reagent, and the first part of the grain to show this change is a rather broad band of material at the margin. Gelatinization begins at the distal margin and progresses in two different ways. In the less resistant grains various discrete points on the margin are affected first, and from these points gelatinization spreads first along the whole distal margin and then towards the hilum. It is preceded by some longitudinal fissuring of the grain, but no separation of particles. When the hilum is reached the bubble first swells, then shrinks, and finally disappears, and the hilum swells rapidly, the material at the proximal end being the last part of the grain to be gelatinized. In the more resistant elongated grains the whole distal margin is affected first and gelatinization then progresses towards the proximal end; when it has reached a point about half the distance between the hilum and the distal end the proximal end is gelatinized and the hilum swells, the bubble swelling first, then shrinking, and finally disappearing. The portion just distal to the hilum is then split into two pieces by a longitudinal fissure, and these two pieces gelatinize separately. In lenticular-shaped grains the process is very similar, except that gelatinzation begins at the margin at either end of the long axis of the

grain and converges from these two points towards the hilum, which is centric; when the hilum is reached it swells, separating the two portions of material on either side of it. The broad grains are very resistant and only occasionally is one gelatinized. In such grains the process is the same as that described for the rapidly reacting grains, except that it is much slower, is not preceded by so much fissuring of the grain, and the grain is not always completely gelatinized.

The gelatinized grains are much swollen, have thick capsules, and are not greatly distorted, but retain some resemblance to the form of the untreated grain.

Comparison of the *chloral hydrate* reactions between *N. poeticus ornatus* and *N. telemonius plenus* shows:

The hilum is not so distinct, and a bubble is less often formed there than in *N. telamonius plenus.* The lamellæ are more distinct and are visible in more grains, and the grains are somewhat more refractive in appearance after the addition of the reagent than in *N. telamonius plenus.* Gelatinization proceeds according to two methods, but there is no marked distinction between less resistant and more resistant grains. In the first, which is seen in the great majority of the grains, gelatinization begins at various discrete points on the margin and is preceded by a pitted appearance of the surface of the grain. It proceeds from the initial points all around the margin until only the proximal margin is not gelatinized, and then inward, the ungelatinized starch being invaded by fissures which separate off small particles until the hilum is reached. The bubble if present swells, shrinks, and finally disappears and the hilum swells, and then the starch at the proximal end is gelatinized. The lenticular grains are gelatinized in the same way described from the lenticular grains of *N. telamonius plenus.* The gelatinized grains are more swollen, their capsules are not so thick, and they are more distorted than in *N. telamonius plenus.*

The reaction with *chromic acid* begins in 30 seconds. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 26 per cent of the total starch in 15 minutes; in about 10 per cent of the grains and 77 per cent of the total starch in 30 minutes; in about 75 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 95 per cent of the grains and in more than 99 per cent of the total starch in 60 minutes. (Chart D 249.) (See footnote, page 516.)

The hilum is distinct, and the lamellæ are moderately distinct in most of the grains, but not visible in some. Gelatinization begins at the hilum and progresses according to but one method. The portion immediately surrounding the hilum, which usually represents the primary starch formation, is cracked and divided into 3 or 4 pieces that are covered by coarse striæ. The rest of the grain, which is usually distinctly a secondary formation, is less coarsely but still very distinctly striated. The grain swells and the cracks widen, in some grains, the primary starch is gelatinized at once and the secondary starch is pushed to the margin, where it forms a striated and lamellated band which gradually becomes apparently homogeneous. It then grows thinner and more nearly transparent, but is dissolved before gelatinization is complete. In other grains the primary starch is cracked into 2 or 3 pieces, which are later subdivided, and as the grain swells and the secondary starch is pushed to the margin, the particles are scattered and arranged around the inner border of the marginal band, where they remain until part of the margin is dissolved and the contents of the capsule flow out of the opening and dissolve in the surrounding reagent.

The grains all begin to dissolve before gelatinization is complete, so that the character of a completely gelatinized grain can not be determined.

Comparison of the *chromic-acid* reactions between *N. poeticus ornatus* and *N. telamonius plenus* shows:

The hilum and lamellæ as a rule are not so distinct, gelatinization progresses according to two methods, one of which is different from the one described for the grains of *N. telamonius plenus.* In the first method several fissures proceed longitudinally from the hilum to the distal margin, dividing this part of the grain into granules and the rest of the grain is distinctly striated. Gelatinization then commences and the inner material becomes granular, while the rest of the material forms a marginal band consisting of two parts which is slowly gelatinized. In the second method, which is seen only in a very small minority of the grains and which is the same as that described for some of the grains of *N. telamonius plenus,* in that the primary does not gelatinize before the secondary starch, but is resistant and is broken up into granules which are scattered around the inner border of the marginal band. Most of the grains are completely gelatinized before they are dissolved, and in this differ from those of *N. telamonius plenus.*

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 33 per cent of the total starch in 15 minutes; in about 39 per cent of the grains and 73 per cent of the total starch in 30 minutes; in about 50 per cent of the grains and 84 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 90 per cent of the total starch in 60 minutes. (Charts D 295, D 296.)

The hilum becomes distinct, unaccompanied by the formation of a bubble. The lamellæ are moderately distinct in all the grains. Gelatinization begins at the hilum and progresses according to three methods. In the first, which is seen in a majority of the grains, the primary material immediately surrounding the hilum is split into 5 or 6 portions, which are usually subdivided into many coarse granules and widely scattered as the grain swells, but which sometimes remain clumped together in the center of the grain, apparently unaffected by the reagent. The secondary starch becomes homogeneous in appearance and somewhat more refractive in small scattered spots and is gelatinized slowly, the more resistant portion forming a nearly homogeneous-looking, refractive band at the margin in which a suggestion of lamellar arrangement is sometimes seen. Around the inner border of this band are usually scattered the granules of the primary starch. The marginal band grows slowly thinner and more nearly transparent and is finally gelatinized; the granules of the primary starch grow smaller more slowly, become more refractive, and finally disappear. In the second method two furrows or fissures extend from the hilum on either side to the

margin, and the starch distal to them and to the hilum loses its structural appearance and becomes a finely granular mass which is invaded by short cracks and fissures at the margin. The material proximal to the furrows and the hilum is very finely striated, and as the distal deposit is slowly gelatinized it forms a finely striated, refractive band at the proximal margin which remains for some time after the distal portion is completely gelatinized, and in some grains is never entirely disorganized. The third method is the same as the first, except that there is no division of the grain into primary and secondary starch and hence no granule formation of the starch immediately surrounding the hilum.

The gelatinized grains are much swollen, have rather thick capsules, and are not greatly distorted.

Comparison of the *pyrogallic-acid* reactions between *N. poeticus ornatus* and *N. telamonius plenus* shows:

The hilum is as distinct, and the lamellæ are at first more but later less distinct than in *N. telamonius plenus.* Gelatinization proceeds according to two of the methods described under *N. telamonius plenus.* In the first method, which is seen in a larger majority of the grains than in *N. telamonius plenus,* the secondary starch is divided by very fine striæ instead of becoming homogeneous in appearance. The primary starch is always divided into granules and scattered to the inner border of the marginal band instead of sometimes remaining clumped in the center of the grain, and the granules are more refractive than in *N. telamonius plenus.* While in the marginal band two layers may be seen—an inner spicular and an outer striated portion—of which the inner is gelatinized first. In the second method there are no differences to be noted between the two starches. The gelatinized grains are more swollen and the capsules are not so thick as in *N. telamonius plenus,* but they are no more distorted than in that starch.

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 3 per cent of the grains and 14 per cent of the total starch in 5 minutes; in about 35 per cent of the grains and 65 per cent of the total starch in 15 minutes; in about 55 per cent of the grains and 75 per cent of the total starch in 30 minutes; in about 60 per cent of the grains and 80 per cent of the total starch in 45 minutes; in about 65 per cent of the grains and 85 per cent of the total starch in 60 minutes. (Chart D 297.)

The hilum becomes distinct, unaccompanied by the formation of a bubble. The lamellæ are moderately distinct in the great majority of the grains and invisible in a few grains. Gelatinization begins at the hilum and progresses according to three types. In the first, which occurs in the majority of the grains, the material around the hilum, which probably represents the primary starch formation, is split into particles of varying size, number, and shape. These particles may be either completely separated from one another and scattered widely as the grain swells or may not be completely separated but remain clumped together, while starch surrounding them, which represents a secondary formation, is completely gelatinized. Gelatinization in this part of the grain is preceded by the appearance of fine striæ radiating in all directions to the margin, then gelatinization of the less resistant part of this starch begins with swelling of the entire grain and the more resistant part is pushed to the margin, where it forms a striated lamellated band, around the inner border of which the particles of the primary starch are arranged. The marginal band grows progressively thinner and more nearly transparent and loses its striated appearance, but the lamellated appearance remains for a long time. In the second method of gelatinization two furrows or fissures extend from the hilum transversely or obliquely nearly to the margin, the material just distal to the hilum is cracked and divided into rather coarse granules, and the starch included between the furrow and the hilum and the distal margin is striated first and then transformed into a mass of very fine granules which is much cracked and fissured at the margin. The portion at the proximal end, which is the most resistant in the whole grain, becomes striated, and as the grain swells forms a striated, lamellated band at the margin of the proximal end and sides nearby, which remains for some time after the distal portion of the grain is completely gelatinized. The third method of gelatinization is the same as the first, except that there is no division of the grain into primary and secondary starch, and there is no granule or fragment formation. The gelatinized grains are much swollen and have thick capsules, but are not much distorted, retaining some resemblance to the form of the untreated grain.

Comparison of the *nitric-acid* reactions of *N. poeticus ornatus* and *N. telamonius plenus* shows:

The hilum is as distinct and the lamellæ are at first more distinct, but later become much less distinct, than in *N. telamonius plenus.* Gelatinization always begins at the hilum and proceeds according to the three methods noted in *N. telamonius plenus,* but there is a much smaller number reacting according to the second and third types described than in *N. telamonius plenus.* In the first type the striæ are not so fine and the fragments into which the primary starch is broken are smaller, more numerous, and more refractive and are more apt to be scattered to the marginal band than to remain clumped together, and the lamellar appearance in the marginal band is not so persistent as in *N. telamonius plenus.* The gelatinized grains are more swollen and the capsules much less thick, but the grains are not much more distorted than in *N. telamonius plenus.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 92 per cent of the entire number of grains and 99 per cent of the total starch in 2 minutes; in more than 99 per cent of the grains and total starch in 5 minutes. (Chart D 298.)

The hilum is distinct and a bubble is formed in the majority of the grains. The lamellæ are moderately distinct in some grains but not in others. Gelatinization begins at the hilum and progresses according to but one method. The primary, which can be clearly distinguished from the secondary starch in all of the grains, is partially separated from the latter deposit by a fissure, and the secondary starch is first divided into concentric groups of lamellæ by irregular fissures and then is rapidly gelatinized. In some grains the primary starch is gelatinized at the same time and in others not until later, becoming granular in the interior and having the more resistant material at the margin as an ordinary simple

grain. The gelatinized grains are much swollen, have rather thick capsules, and are much distorted.

Comparison of the *sulphuric-acid* reactions between *N. poeticus ornatus* and *N. telamonius plenus* shows:

A bubble is not so often formed at the hilum as in *N. telamonius plenus,* and the lamellæ are less distinct than in the grains of that starch. Gelatinization progresses according to two methods, one of which is in general the same as that described in *N. telamonius plenus* and occurs in the majority of the grains of *N. poeticus ornatus.* The main points of difference noted are that the primary starch is gelatinized more nearly at the same time as the secondary starch, instead of later, and there is very rarely preliminary fissuring of the secondary starch by concentric fissures. In the second method 2 furrows or actual fissures extend transversely or sometimes obliquely from either side of the hilum nearly to the margin, and the starch included between them is transformed into a finely granular mass which often shows somewhat of a lamellar arrangement. This lamellated appearance is quickly lost and the whole melts down into a gelatinous mass with much swelling and distortion of the capsule. The more resistant material at the proximal end and sides nearby is pushed to the margin, where it forms a homogeneous-looking, refractive marginal band which is soon gelatinized. The gelatinized grains are much swollen, have thicker capsules, and are more distorted than those of *N. telamonius plenus.*

Narcissus doubloon (Hybrid).

(Plate 11, fig. 63; Charts D 293 to D 298.)

Histologic Properties.

In *form* the grains are usually simple and isolated, and there are fewer aggregates and compound grains than in either parent. The compound grains belong to the same types in the same order of frequency of occurrence as in *N. telamonius plenus.* The aggregates are the same as in both parents. There are not so many simple grains in which a primary grain is seen surrounded by several layers of secondary starch as in *N. telamonius plenus,* but more than in *N. poeticus ornatus.* The grains are usually regular, as in *N. telamonius plenus,* and any irregularities which occur are due to the same causes, with the addition of two which are seen in *N. poeticus ornatus* and which are: (1) Pressure facets on the sides and distal end, and (2) regular, radiating elevations and depressions in the surface and margin, giving a fluted appearance to the grain. The conspicuous forms are: Nearly round, broad, ovoid and slender ovoid, elliptical, and irregularly polygonal. The additional forms are lenticular, dome-shaped, plano-convex, clam-shell, and pyriform. The grains are not flattened.

In form *N. doubloon* shows a somewhat closer relationship to *N. telamonius plenus* than to *N. poeticus ornatus,* though the three starches resemble one another closely.

The *hilum* when not fissured is as distinct as in *N. telamonius plenus;* it is as often fissured as in that starch; and the fissures have the same forms and the forms have the same order of frequency of occurrence. The hilum is sometimes centric, but in the great majority of the grains is eccentric from 0.45 to 0.27, usually 0.34, of the longitudinal axis.

In the character of the hilum *N. doubloon* shows a somewhat closer relationship to *N. telamonius plenus* than to *N. poeticus ornatus.* The degree of eccentricity so nearly corresponds in all three starches that no satisfactory differentiation can be based on this point.

The *lamellæ* are, as in *N. telamonius plenus,* moderately distinct, rather coarse, continuous rings which follow the form of the outline of the grain, and are more distinct in the secondary than in the primary starch of those grains. The number counted on the larger grains varies from 6 to 12, usually 8.

In the character of the lamellæ *N. doubloon* shows a closer relationship to *N. telamonius plenus* than to *N. poeticus ornatus.*

The *size* of the grains varies from the smaller which are 3 by 3μ, to the larger which are 20 by 30μ and 22 by 24μ, in length and breadth. The common sizes are 16 by 16μ, 8 by 16μ, and 16 by 10μ.

In size *N. doubloon* shows a somewhat closer relationship to *N. poeticus ornatus* than to *N. telamonius plenus.* It is much smaller than either of the parents, which are very close to one another; but *N. poeticus ornatus* is slightly smaller than *N. telamonius plenus.*

Polariscopic Properties.

The *figure* is moderately distinct and somewhat more poorly defined than in *N. poeticus ornatus.* The lines cross at an acute angle and are as often bent and bisected as in *N. poeticus ornatus.* The figure, however, is more frequently in the form of a conjugate hyperbola or of a long line bisected at both ends than in that starch.

The *degree of polarization* varies from low to very high (value 45) the same as in *N. telamonius plenus,* with the same proportion of grains with a moderate, a high, and a very high degree of polarization and the same amount of variation in a given aspect of the individual grains.

With *selenite* the quadrants, as in *N. poeticus ornatus,* are moderately well defined, unequal in size, and often irregular in shape. The colors are usually not pure.

In the character of the figure and the appearance with selenite *N. doubloon* shows a closer relationship to *N. poeticus ornatus,* and in the degree of polarization to *N. telamonius plenus.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains are all colored a moderate violet tinged with blue (value 45), the same as in *N. telamonius plenus,* and the color deepens with moderate rapidity until they are very deeply colored and have more of a bluish tint. With 0.125 per cent Lugol's solution the grains are all colored a light violet, the same as in *N. telamonius plenus.* After heating in water until all the grains are gelatinized and then adding a 2 per cent Lugol's solution, the gelatinized *grains* all color a moderate indigo and the *solution* a deep indigo, as in *N. telamonius plenus.* If the preparation is boiled for 2 minutes and a 2 per cent Lugol's solution is then added, most of the *grain-residues* color a light indigo, but in some only the capsules are stained; the *capsules* color a reddish violet and the *solution* a very deep indigo-blue, as in *N. telamonius plenus.*

Qualitatively and quantitatively the reaction with iodine of *N. doubloon* shows a closer relationship to *N. telamonius plenus* than to *N. poeticus ornatus.*

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes they are light to moderately colored (value 33), less than in *N. telamonius plenus,* but somewhat more than in *N. poeticus ornatus.*

With *safranin* the grains all color very lightly at once, and in 30 minutes they are moderately colored (value 45), the same as in *N. poeticus ornatus.*

In the reactions with aniline stains *N. doubloon* shows a closer relationship to *N. poeticus ornatus* than to *N. telamonius plenus.*

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 71.2° to 73° C., and of all is 75° to 77° C., mean 76° C. The temperature of gelatinization of *N. doubloon* is not so close to that of *N. telamonius plenus* as to that of *N. poeticus ornatus.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 1 minute. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 9 per cent of the grains and 13 per cent of the total starch in 15 minutes; in about 30 per cent of the grains and 38 per cent of the total starch in 30 minutes; in about 48 per cent of the grains and 50 per cent of the total starch in 45 minutes; in about 50 per cent of the grains and 54 per cent of the total starch in 60 minutes. (Chart D 293.)

A bubble is formed at the hilum as frequently as in *N. poeticus ornatus,* and the lamellæ are not so often visible as in either parent. The portion of the grain at the margin which first becomes more refractive is as narrow and as refractive as in *N. poeticus ornatus.* Gelatinization begins at the distal margin or to one side of the distal margin, as in *N. telamonius plenus.* The progress of gelatinization is the same as that noted for the three types of the more resistant grains of *N. telamonius plenus.* The only differences noted are that the proximal end is usually more resistant, and the portion just distal to the hilum is less frequently split by a fissure. The gelatinized grains are more swollen and the capsule is not quite so thick and the grains are more distorted than in *N. telamonius plenus,* but the capsule is thicker and the grains less distorted than in *N. poeticus ornatus.*

In this reaction *N. doubloon* shows qualitatively a closer relationship to *N. telamonius plenus* than to *N. poeticus ornatus.*

The reaction with *chromic acid* begins in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 10 per cent of the total starch in 15 minutes; in about 14 per cent of the grains and 76 per cent of the total starch in 30 minutes; in about 43 per cent of the grains and 90 per cent of the total starch in 45 minutes; in about 67 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 294.) (See footnote, page 516.)

The hilum and lamellæ are as distinct as in *N. poeticus ornatus.* Gelatinization begins at the hilum and proceeds according to the two methods described under *N. poeticus ornatus,* except that there are more grains in which is seen the second method described from but a small minority of the grains of *N. poeticus ornatus,* and the striæ which appear in the secondary starch are coarser and more distinct. Most of the grains are completely gelatinized before they are dissolved and are as much swollen, have as thick capsules, and are no more distorted than in *N. poeticus ornatus.* In this reaction *N. doubloon* shows qualitatively a closer relationship to *N. poeticus ornatus* than to *N. telamonius plenus.*

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 35 per cent of the total starch in 15 minutes; in about 38 per cent of the grains and 67 per cent of the total starch in 30 minutes; in about 52 per cent of the grains and 80 per cent of the total starch in 45 minutes; in about 57 per cent of the grains and 84 per cent of the total starch in 60 minutes. (Chart D 295.)

A number of moderately small grains in this preparation, as in many other narcissi, are quite resistant, which results in keeping the percentages of the total starch lower than in some other species where smaller percentages of grains may undergo complete gelatinization, and yet the percentages of total starch be greater.

The hilum is as distinct as in both parents and the lamellæ as distinct as in *N. poeticus ornatus.* Gelatinization begins at the hilum and progresses according to three types described under *N. telamonius plenus.* A smaller majority than in either parent follows the first method, as in *N. telamonius plenus,* and the only differences noted between the hybrid and that starch are that the granules of the primary starch do not remain clumped in the center of any of the grains, but, as in *N. poeticus ornatus,* are always scattered to the inner border of the marginal band. A large minority follows the second method, and a very few the third method, exactly as in *N. telamonius plenus.* The gelatinized grains are as much swollen and have as thick capsules as in *N. poeticus ornatus,* and are somewhat more distorted than in either parent. In this reaction *N. doubloon* shows qualitatively a somewhat closer relationship to *N. telamonius plenus* than to *N. poeticus ornatus.*

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 27 per cent of the total starch in 5 minutes; in about 18 per cent of the grains and 60 per cent of the total starch in 15 minutes; in about 42 per cent of the grains and 72 per cent of the total starch in 30 minutes; in about 48 per cent of the grains and 75 per cent of the total starch in 45 minutes; in about 57 per cent of the grains and 81 per cent of the total starch in 60 minutes. (Chart D 297.)

The hilum is as distinct as in the parents, and the lamellæ are not so distinct at any time as in *N. telamonius plenus,* but remain distinct much longer than in *N. poeticus ornatus.* Gelatinization, as in the parents, begins at the hilum and proceeds according to the three types already described. There is a small majority—a smaller number than in either parent—which follows closely the first types described under *N. telamonius plenus,* the only differences noted being that the granules

are much more often scattered instead of remaining clumped together and the lamellated appearance of the marginal band is not so persistent. A large minority follows the second type as described in *N. telamonius plenus,* and a very few follow the third type. The gelatinized grains are as much swollen and have the same size capsules as in *N. poeticus ornatus* and are more distorted than in either parent. In this reaction *N. doubloon* shows qualitatively a closer relationship to *N. telamonius plenus* than to *N. poeticus ornatus.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 82 per cent of the entire number of grains and 97 per cent of the total starch in 2 minutes; in more than 99 per cent of the grains and total starch in 5 minutes. (Chart D 298.)

The hilum and lamellæ are as distinct and a bubble is as frequently formed at the hilum as in *N. telamonius plenus.* Gelatinization begins at the hilum and progresses according to the two methods described under *N. poeticus ornatus,* only one of which is seen in *N. telamonius plenus.* A somewhat larger majority of the grains follows the first method described than in *N. poeticus ornatus,* but there are no marked differences, except that the secondary starch is usually divided into portions of varying size by irregular concentric fissures, as in *N. telamonius plenus.* In the second method there are no marked differences between the hybrid and *N. poeticus ornatus.* The gelatinized grains are as much swollen, have as thick capsules, and are as much distorted as in *N. poeticus ornatus.* In this reaction *N. doubloon* shows, qualitatively, a somewhat closer relationship to *N. poeticus ornatus* than to *N. telamonius plenus.*

17. Starches of Narcissus princess mary, N. poeticus poetarum, and N. cresset.

Starch of *N. poeticus poetarum* is described on pages 519 to 522.

N. princess mary (Seed Parent).

(Plate 11, fig. 64; Charts D 299 to D 304.)

Histologic Properties.

In *form* the grains are usually simple and isolated. There is a moderate number of aggregates and few compound grains. The compound grains belong to two types in their order of frequency of occurrence: (1) A number of hila irregularly placed in an amorphous-looking mass of starch which is surrounded by 1 or 2 layers or lamellæ of secondary starch; (2) 2 small grains of equal size surrounded by 2 to 4 common secondary lamellæ. The aggregates are usually of 2 grains of equal size adherent at the distal ends or sides, though they may consist of 3 grains linearly arranged. In a large minority of the simple grains a primary and a secondary formation of starch may be clearly distinguished. The grains are usually somewhat irregular in form and the irregularities are due to the following causes: (1) Numerous small, irregular depressions and elevations in the surfaces and around the margins of the grains; (2) a few large depressions and rounded protuberances, usually at the distal end, but occasionally at the proximal end or sides; (3) irregularly placed pressure facets; (4) rarely, regular radiating elevations and depressions in the surface near the distal end giving a fluted appearance to the grain. The conspicuous forms are ovoid, nearly round, and plano-convex. The additional forms are dome-shaped, triangular, lenticular, and elliptical. The grains are not flattened.

The *hilum,* when it is not fissured, is a distinct, round, rarely, elongated, lenticular spot. It is fissured in the great majority of the grains and the fissures have the following forms in the order of their frequency of occurrence: (1) Cruciate; (2) **T-Y**,- or **X**-shaped; (3) longitudinal line which is often somewhat branched, a dragon-fly figure; (4) a single straight, transverse, or occasionally two parallel transverse lines, are seen, one distal to the hilum and one passing through it; (5) a number of fissures arranged in an irregularly stellate fashion. The hilum is sometimes centric, but in the great majority of the grains it is eccentric from 0.43 to 0.29, usually 0.36, of the longitudinal axis.

The *lamellæ* are not visible in many grains, and when they are visible, are never very distinct. They are continuous rather coarse rings which conform in general to the outline of the grain, but only near the margin do they follow the contour closely. The number counted on some of the larger grains varies from 6 to 12.

The *size* of the grains varies from the smaller which are 4 by 4μ, to the larger which are 30 by 42μ and 22 by 42μ, in length and breadth. The common sizes are 28 by 28μ, 28 by 34μ, and 15 by 30μ.

Comparison of the *histologic characteristics* between *N. poeticus poetarum* and *N. princess mary* shows:

There are more compound grains and more aggregates. The compound grains belong to three types, two of which are the same as those described in *N. princess mary,* and the third consists of a large grain to the side or end of which a small grain has become adherent and both are inclosed in 2 or 3 common secondary lamellæ. The aggregates of the simple grains are of the same character as in *N. princess mary,* and there are in addition aggregates of compound grains and of one compound and one simple grain. The grains are somewhat more irregular in shape and the irregularities are due to the same causes and also to two small notches in the margin at either side of the proximal apex. The former are more numerous and more varied and somewhat more rounded as a rule. The grains are not flattened.

The *hilum* is more distinct when not fissured and it is not quite so frequently fissured; the fissures are deeper and more extensive but have the same forms as in *N. princess mary,* with the exception of the 2 parallel transverse fissures, which do not occur in these grains. The hilum is very nearly as eccentric as in *N. princess mary,* the average eccentricity being 0.38 of the longitudinal axis.

The *lamellæ* are more often moderately distinct and not so coarse, but are otherwise the same as in *N. princess mary.*

In *size* the large grains are larger, and there are more large grains, than in *N. princess mary.* The common sizes are very nearly the same.

Polariscopic Properties.

The *figure* in most of the grains is moderately distinct and well defined, but in some grains is neither distinct nor well defined. The lines usually cross one another at acute angles of varying size, but sometimes at right angle. They are often bent and sometimes bisected.

The figure is not always a cross, but sometimes has the form of a conjugate hyperbola, or of a long line bisected at both ends.

The *degree of polarization* varies from low to high (value 35). There are very few grains which have as high a degree of polarization, most of them being low or moderate. There is a little variation in the same aspect of an individual grain.

With *selenite* the quadrants are usually not clean-cut, and are unequal in size and often irregular in shape. The colors are rarely pure and there are very few which have a greenish tinge.

Comparison of the *polariscopic properties* between *N. poeticus poetarum* and *N. princess mary* shows:

The *figure* is as distinct, but not so often well defined. The lines cross at an acute angle, of more variable size, and are more apt to be bent and bisected. There are also more figures which have the forms of a conjugate hyperbola, or a long line bisected at both ends.

The *degree of polarization* is somewhat more nearly moderate (value 40), there are more grains with a high and a moderate degree of polarization than in *N. princess mary,* and there is some variation in a given aspect of an individual grain.

With *selenite* the quadrants are less often clean-cut and are more irregular in shape. The colors are more often pure and there are more grains which have a greenish tinge.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a light to moderate violet tinged with blue (value 42), and the color deepens with moderate rapidity until all the grains are very deeply colored and bluer in tint. With 0.125 per cent Lugol's solution the grains all color a light violet, and the color deepens with moderate rapidity until the grains are deeply colored and have a bluish tint. After heating in water until all the grains are gelatinized and then adding a 2 per cent Lugol's solution, the gelatinized *grains* color a deep or a moderate indigo, and the *solution* a moderate indigo. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the *grain-residues* color a moderate or a light to moderate indigo, the *capsules* a reddish violet, and the *solution* a deep indigo.

Comparison of the *iodine reactions* between *N. poeticus poetarum* and *N. princess mary* shows:

With 0.25 per cent Lugol's solution the grains color somewhat more than in *N. princess mary* (value 45), and so also with 0.125 per cent solution. After heating in water until the grains are all gelatinized and then adding a 2 per cent Lugol's solution, the gelatinized grains color less and the solution more than in *N. princess mary.* After heating for 2 minutes and then adding a 2 per cent Lugol's solution, the grain-residues are less and the solution is more deeply colored than in *N. princess mary.*

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes they are light to moderately colored (value 37). The grains are all equally stained and there is no variation in depth of color in different parts of the individual grains.

With *safranin* the grains all color very lightly at once, and in 30 minutes they are moderately colored (value 50), more than with gentian violet. The grains are all equally stained and there is no variation in depth of color in different parts of the individual grains.

Comparison of the *aniline reactions* between *N. poeticus poetarum* and *N. princess mary* shows:

With gentian violet the grains are somewhat more lightly stained (value 35) than in *N. princess mary,* and with safranin, they are stained to the same depth (value 50).

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 70° to 72° C., and of all is 74° to 76° C., mean 75° C.

Comparison of the *temperature reactions* between *N. poeticus poetarum* and *N. princess mary* shows:

The temperature of gelatinization is much lower than that of *N. princess mary,* 71° to 73° C., mean 72° C., a difference of 3° C. mean.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 6 per cent of the total starch in 30 minutes; in about 6 per cent of the grains and 8 per cent of the total starch in 45 minutes; in about 11 per cent of the grains and 15 per cent of the total starch in 60 minutes. (Chart D 299.)

The hilum is not distinct unless a bubble appears there, and a rather large bubble is formed in about one-third of the total number of grains. The lamellæ are not visible at any time during the reaction. The grains become more refractive after the addition of the reagent, and in many grains the first portion to show this is a rather narrow band of starch at the margin, but many other grains show at once all over the surface an increased refractivity. Gelatinization begins at one or two points on the margin, usually at the distal end. In the slender ovoid, lenticular, and elliptical grains, which are less resistant than the broader forms, gelatinization spreads from the initial points until the whole distal margin is gelatinized and the reaction proceeds toward the hilum, preceded by longitudinal fissuring of the ungelatinized starch and by separation of particles of this material, which float off and are gelatinized; the hilum when reached swells rapidly, and the bubble if present swells, then shrinks, and finally disappears, and the proximal portion gradually gelatinizes last. In the broad, more resistant forms gelatinization proceeds toward the hilum from the initial points, so that great cup-shaped depressions are hollowed out of the ungelatinized starch. These depressions draw nearer to one another until they finally coalesce; when the hilum is reached it swells rapidly, and the bubble, if present, swells, then shrinks, and finally disappears, and the proximal starch, which is the last to be gelatinized, is then rapidly gelatinized.

The gelatinized grains are much swollen and have moderately thick capsules. They are considerably distorted, and do not bear any resemblance to the form of the untreated grain.

Comparison of the *chloral-hydrate* reactions between *N. poeticus poetarum* and *N. princess mary* shows:

A bubble is less frequently found at the hilum, and the lamellæ, though at first not visible as in *N. princess mary,* later become moderately distinct. In all the grains the portion at the margin is the first part to become more refractive after the addition of the reagent instead of the whole grain becoming equally refractive, as in so many grains of *N. princess mary.* Gelatinization begins at various points on the margin, not confined to the distal end as in most of the grains of *N. princess mary,* and proceeds in two ways, the one occurring in the minority of the grains being the same as that described for the broad resistant grains of *N. princess mary.* The other method which occurs in the majority of the grains is not seen in any grains of *N. princess mary.* The marginal deposit is all gelatinized except a narrow strip just at the proximal end. Then gelatinization, preceded by a pitted appearance of the ungelatinized starch, follows division of this strip by numerous fissures. These fissures split off small particles, which float away and are gelatinized. When the hilum is reached it swells suddenly and the proximal end is the last to be gelatinized. The gelatinized grains are more swollen and have thin capsules. They are more distorted than those of *N. princess mary.*

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the grains and 2 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 25 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 70 per cent of the total starch in 30 minutes; in about 30 per cent of the grains and 90 per cent of the total starch in 45 minutes; in about 60 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 300.) (See footnote, page 516.)

The hilum is distinct and a bubble is now formed there. The lamellæ are moderately distinct in some of the grains and not visible in others. Gelatinization begins at the hilum and progresses according to two methods. In the first, which is noted in the great majority of the grains, 2 furrows are seen extending transversely from the hilum on either side to the margin. The starch included between these furrows, the hilum, and the margin is divided up into granules by fine, irregular fissures or channels which radiate from the hilum to the margin. The granules so formed are especially large, refractive, and distinct near the hilum. The starch at the proximal end and sides nearby becomes indistinctly striated, and as the distal material is gelatinized and the grain swells it is pushed to the margin, where it forms a compact, rather coarse distinctly striated band which later unites with a similar band formed of the more resistant distal starch all around the margin. The striation gradually disappears and the band becomes thinner and more nearly transparent, and finally is gelatinized, leaving only the capsule, the proximal portion being the last to be gelatinized. In the second method the primary material around the hilum is divided into 3 or 4 pieces by fissures and these pieces stay clumped together as the rest of the grain gelatinizes and then slowly become smaller, more refractive, and more widely separated, and finally disappear. The secondary starch meanwhile is gelatinized from within outward, the less resistant substance swelling and forcing the more resistant deposit to the margin, where it forms a striated and often lamellated band which gradually grows thinner and loses its striated appearance and is finally gelatinized. The grains are nearly always completely gelatinized before solution takes place. The gelatinized grains are much swollen, have rather thin capsules, and are somewhat distorted.

Comparison of the *chromic-acid* reactions between *N. poeticus poetarum* and *N. princess mary* shows:

The hilum and lamellæ are somewhat more distinct, and gelatinization progresses according to two types, one of which has been already described for the majority of the grains of *N. princess mary.* The latter is seen in more grains than in *N. princess mary* and differs from the method in that grain in that there is not so much irregular fissuring and the bands of resistant material do not so often extend around the whole margin. In the second type a number of fissures extend from the hilum to the distal margin, dividing the starch in their path into irregular granules. This granular portion now begins to gelatinize and the grain swells and the more resistant starch is pushed to the margin, where it forms a striated band which is thinner at the distal margin and which gradually loses its striated appearance and becomes thinner and more nearly transparent. The gelatinized grains are much swollen, have thinner capsules and are more distorted than in *N. princess mary.* They often are dissolved before gelatinization is complete.

The reaction with *pyrogallic acid* begins in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 40 per cent of the total starch in 15 minutes; in about 43 per cent of the grains and 77 per cent of the total starch in 30 minutes; in about 57 per cent of the grains and 87 per cent of the total starch in 45 minutes; in about 67 per cent of the grains and 95 per cent of the total starch in 60 minutes. (Charts D 301 and D 302.)

The hilum is distinct. The lamellæ are moderately distinct, and a lamellated appearance often persists for a considerable time at the margin of the gelatinized grains. Gelatinization begins at the margin and progresses according to two methods. In the first, which is seen in the great majority of the grains, 2 refractive furrows extend transversely or, rarely, obliquely, from either side of the hilum nearly to the margin and the starch included between them, the hilum and all but the portion immediately at the margin are first irregularly divided by fine, branching fissures and then become a refractive homogeneous-looking mass which slowly is gelatinized from the hilum outward. The more resistant starch at the proximal end and sides nearby is striated and, then as the grain swells, forms in connection with a thinner band of starch forming the rest of the margin, a refractive striated band which very slowly grows thinner and more refractive and finally is completely gelatinized. In the second method the primary starch is split into a number of small particles or rather coarse granules, and the secondary starch becomes finely striated and the less resistant portion is gelatinized and the whole grain slowly swells. The more resistant part of the primary starch is pushed to the margin, where it forms a rather homogeneous-looking, refractive band around

the inner border of which are arranged the granules of the primary starch. These granules are very resistant and often remain for a long time after the rest of the grain is gelatinized.

The gelatinized grains are much swollen, have rather thick capsules, and are considerably distorted.

Comparison of the *pyrogallic-acid* reactions between *N. poeticus poetarum* and *N. princess mary* shows:

The hilum and lamellæ are more distinct, and gelatinization proceeds according to two methods, which are very nearly the same as the two methods described under *N. princess mary*. In the first method, which occurs in a small majority of the grains and which is the same in general as that described for a great majority of the grains of *N. princess mary*, the main points of difference noted are that a band is not formed about the entire margin, but only at the proximal end and sides nearby, and that there is not so much preliminary fissuring of the distal material. In the second method the main points of difference noted are that the granules formed from the primary starch are smaller and more numerous and the striæ in the secondary starch are not so fine and are more distinct. The gelatinized grains are more swollen, have thinner capsules, and are more distorted than in *N. princess mary*.

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 13 per cent of the total starch in 5 minutes; in about 21 per cent of the grains and 55 per cent of the total starch in 15 minutes; in about 29 per cent of the grains and 68 per cent of the total starch in 30 minutes; in about 34 per cent of the grains and 75 per cent of the total starch in 45 minutes; in about 44 per cent of the grains and 79 per cent of the total starch in 60 minutes. (Chart D 303.)

The hilum is distinct and no bubbles are formed there. The lamellæ are moderately distinct, and a lamellated appearance often persists at the margin of the grain after the rest of the grain is gelatinized. Gelatinization begins at the hilum and follows two methods of procedure. In the first type, which is seen in the great majority of the grains, 2 refractive furrows or actual fissures extend either transversely or obliquely from the hilum to the distal margin, and the material included between them and the hilum and the last 2 or 3 rows of lamellæ at the margin is transformed into a finely granular mass which is gelatinized from the hilum outward. In the meantime the more resistant starch at the proximal end is divided by fine radiating striæ, and as the grain swells, due to the gelatinization and swelling of the distal portion, it forms a striated and lamellated band at the proximal margin and sides nearby which is joined to a similar band formed from the last 2 or 3 lamellæ around the rest of the margin. This grows progressively thinner and more nearly transparent, and loses the striated appearance but retains the lamellated structure for a long time. In the second type of procedure, the grain consists of a primary and a secondary formation of starch, and as the hilum swells the primary starch which immediately surrounds the hilum is split into a number of small fragments. The secondary starch in the meantime is divided by fine striæ. As gelatinization of the less resistant starch proceeds, and swelling of the whole grain occurs, the more resistant portions of both primary and secondary starches are pushed to the margin. Here the secondary starch forms a striated and lamellated marginal band, around the inner border of which are arranged the small fragments of the primary starch which are then quickly gelatinized. The marginal band persists for some time, growing progressively thinner and more nearly transparent and losing the striated appearance, but retaining the lamellated structure for some time after the rest of the grain has been gelatinized. The gelatinized grains are much swollen and have rather thick capsules. They are considerably distorted and do not retain much resemblance to the form of the untreated grain.

Comparison of the *nitric-acid* reactions between *N. poeticus poetarum* and *N. princess mary* shows:

The hilum and lamellæ are more distinct. Gelatinization proceeds according to the two methods described under *N. princess mary*, and a much smaller majority of the grains follows in the main details the first method described, the differences noted being that the striation at the proximal end is much more pronounced and lamellation is more distinct and somewhat more persistent, and a striated, lamellated marginal band is not formed about the whole margin, but only at the proximal end and sides nearby. A much larger number than in *N. princess mary* follows the second method described, the differences noted being that the granules formed from the primary starch are smaller and much more refractive and resistant, and the striæ in the secondary starch are not so fine and are more distinct. The gelatinized grains are more swollen, have thinner capsules, and are more distorted than in *N. princess mary*.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 79 per cent of the entire number of grains and 95 per cent of the total starch in 2 minutes; in more than 99 per cent of the grains and total starch in 5 minutes. (Chart D 304.)

The hilum is distinct and a bubble is formed there in a large minority of the grains. The lamellæ are usually moderately distinct. Gelatinization begins at the hilum and progresses according to two methods. In the great majority of the grains 2 furrows extend transversely from either side of the hilum to the margin, and the starch included between them, the margin, and the hilum melts down into a very finely granular mass which rapidly gelatinizes, with much swelling of the grain and considerable distortion of the capsules. The deposit at the proximal end and sides nearby meanwhile forms a very refractive homogeneous-looking band at the margin which unites with a similar thinner band of resistant material which remains around the rest of the margin, and after the remainder of the substance of the grain is gelatinized grows rapidly thinner and is finally also gelatinized. In the second method the starch immediately around the hilum is cracked into several pieces, and as the rest of the grain swells and the more resistant material forms a refractive, homogeneous-looking marginal band, these particles are scattered and arranged around the inner border. They are more resistant than the rest of the grain and persist for some time after the rest of the grain has gelatinized. The gelatinized grains are much swollen, have rather thin capsules, and are considerably distorted.

Comparison of the *sulphuric-acid* reactions between *N. poeticus poetarum* and *N. princess mary* shows:

The hilum and lamellæ are more distinct and a bubble is not so often formed at the hilum. Gelatinization progresses according to two methods which resemble closely the two already described under *N. princess mary.* The one occurring in a small majority of the grains is that which is seen in a great majority of the grains of *N. princess mary,* the main points of difference being that the starch included between the furrows, the hilum, and the margin is divided by fissures into irregular, concentric groups of lamellæ, while the primary starch is separated from the secondary by a fissure. Then it all melts down into a finely granular mass and the rest of the reaction progresses as in *N. princess mary.* In the second method the main differences noted are, as in the first, the preliminary separation of the primary from the secondary starch and the separation of the secondary starch into concentric groups of lamellæ by irregular fissures. The gelatinized grains are more swollen, have thinner capsules, and are more distorted than in *N. princess mary.*

Narcissus cresset (Hybrid).

(Plate 11, fig. 66; Charts D 299 to D 304.)

Histologic Properties.

In *form* the grains are usually simple and isolated, but there are more aggregates and compound grains than in either parent. The compound grains belong to the three types described under *N. poeticus poetarum* and the one which occurs most frequently is that in which 1, 2, or 3 small grains are adherent to one large grain and all are surrounded by 1 or 2 common secondary lamellæ. The aggregates are the same as in both parents. There are but few grains in which a clear distinction may be made between primary and secondary starch formation, in which respect *N. cresset* is closer to *N. princess mary.* The grains are as irregular as in *N. poeticus poetarum* and the irregularities are due to the same causes as in that starch. The conspicuous forms are plano-convex, ovoid, elliptical, and irregularly quadrilateral. The additional forms are bottle-shaped, triangular with curved base, clam-shell-shaped, broad reniform, and lenticular. The grains are not so varied in form as in *N. poeticus poetarum,* but are somewhat more varied than in *N. princess mary.* In form *N. cresset* shows a somewhat closer relationship to *N. poeticus poetarum* than to *N. princess mary.*

The *hilum,* when not fissured, is as distinct as in *N. princess mary;* it is fissured as often as in *N. poeticus poetarum,* but the fissures have the same character and forms as in *N. princess mary.* The hilum is sometimes centric, but in the majority of the grains it is eccentric from 0.45 to 0.28, usually 0.35, of the longitudinal axis. In the character and eccentricity of the hilum *N. cresset* shows a somewhat closer relationship to *N. princess mary* than to *N. poeticus ornatus.*

The *lamellæ* are more often moderately distinct than in *N. princess mary,* but as often as in *N. poeticus poetarum,* and are rather coarse as in the latter starch. In other characters they are the same as those of *N. poeticus poetarum.* The lamellæ counted on the larger grains vary from 8 to 14, usually 12.

In the character of the lamellæ *N. cresset* shows a somewhat closer relationship to *N. poeticus poetarum* than to *N. princess mary,* though there are but few and slight differences to be noted between any of the three starches in this respect.

In *size* the grains vary from the smaller which are 4 by 4μ, to the larger which are 32 by 44μ, and, rarely, 42 by 34μ, in length and breadth. The common sizes are 32 by 30μ, 30 by 33μ, and 24 by 28μ.

In size *N. cresset* shows a somewhat closer relationship to *N. princess mary* than to *N. poeticus poetarum.*

Polariscopic Properties.

The *figure* is moderately distinct and not well defined as in *N. poeticus poetarum.* The lines cross at angles of widely varying size, and are somewhat less often bent and bisected than in *N. poeticus poetarum,* but more often than in *N. princess mary.* The figure has the form of a conjugate hyperbola, or a long line bisected at both ends as often as in *N. poeticus poetarum.*

The *degree of polarization* varies from low to high (value 40) as in *N. poeticus poetarum,* and there is the same amount of variation in a given aspect of the individual grains.

With *selenite* the quadrants are as poorly defined, as unequal in size, as irregular in shape, and the colors are as often impure as in *N. poeticus poetarum.*

In the degree of polarization, the character of the figure, and the appearance with selenite *N. cresset* shows a closer relationship to *N. poeticus poetarum* than to *N. princess mary.*

Iodine Reactions.

With 0.25 per cent Lugol's solution, the grains all color a light to moderate violet tinged with blue (value 45), the same as in *N. poeticus poetarum* and somewhat more than in *N. princess mary,* and the color deepens with moderate rapidity until the grains are very deeply colored and have more of a bluish tint. With 0.125 per cent of Lugol's solution they are colored a light violet, as light as in *N. poeticus poetarum,* and the color deepens with moderate rapidity until they are deeply colored and have a bluish tint. After heating in water until all the grains are completely gelatinized, and then adding a 2 per cent Lugol's solution, the gelatinized *grains* all color a moderate indigo, and the *solution* a deep indigo, the same as in *N. poeticus poetarum.* If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, most of the *grain-residues* color a light to moderate indigo, and in a few only the capsules are colored; the *capsules* all color a red or a reddish violet, and the *solution* a very deep indigo-blue. Qualitatively and quantitatively the reactions with iodine show a closer relationship to *N. poeticus poetarum* than to *N. princess mary.*

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes they are light to moderately colored (value 37), the same as in *N. princess mary* and more than in *N. poeticus poetarum.*

With *safranin* the grains all color very lightly at once, and in 30 minutes they are moderately colored (value 50), the same as in both parents.

In the reaction with gentian violet *N. cresset* shows a somewhat closer relationship to *N. princess mary* than to *N. poeticus poetarum*, but with safranin the colorings are the same for the three starches.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 71° to 73° C., and of all 74.5° to 76° C., mean 75.7° C.

The temperature of gelatinization of *N. cresset* is the highest and is closer to *N. princess mary* than to *N. poeticus poetarum.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 3 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 7 per cent of the total starch in 30 minutes; in about 15 per cent of the grains and 18 per cent of the total starch in 45 minutes; in about 18 per cent of the grains and 22 per cent of the total starch in 60 minutes. (Chart D 299.)

A bubble is formed at the hilum in a small majority of the grains, more often than in either parent. The lamellæ, as in *N. princess mary*, are not visible at any time during the reaction. The grains usually become refractive at once in all parts, as do many of the grains of *N. princess mary*. Gelatinization begins at various points on the distal margin, and in the less resistant grains, which are slender, ovoid, or elliptical in shape, the process is the same as that described under *N. princess mary*. In the more resistant broad forms two methods of gelatinization are noted: one, in which gelatinization extends around the margin on both sides nearly to the proximal end, is similar to that described for the majority of the grains of *N. poeticus poetarum*, except that serial separation and gelatinization of one or two groups of marginal lamellæ are seen in addition to the fissuring and separation of particles noted in *N. poeticus poetarum;* the other method is the same as that described for the non-resistant forms in *N. princess mary* and for a minority in *N. poeticus poetarum.*

The gelatinized grains are as much swollen, have as thick capsules, and are as much distorted as those of *N. princess mary.*

In this reaction *N. cresset* shows qualitatively a closer relationship to *N. princess mary* than to *N. poeticus poetarum.*

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 15 per cent of the total starch in 15 minutes; in about 20 per cent of the grains and 70 per cent of the total starch in 30 minutes; in about 30 per cent of the grains and 93 per cent of the total starch in 45 minutes; in about 50 per cent of the grains and 96 per cent of the total starch in 60 minutes. (Chart D 300.) (See footnote, page 516.)

The hilum is as distinct and the lamellæ are as often indistinct as in *N. princess mary*. Gelatinization begins at the hilum and progresses according to three types, two of which have been already described under *N. princess mary* and one under both *N. princess mary* and *N. poeticus poetarum*. A small majority of the grains follows the method described for the majority of the grains of both parents, and only a few scattered grains follow the second method described under *N. princess mary*. In the third method, which is not seen in the parents, the hilum swells somewhat and the grain is divided by rather fine striæ which gradually become coarse. The less resistant material is gelatinized and the more resistant forms at the margin a striated indistinctly lamellated band which gradually grows thinner and more nearly transparent until it is gelatinized and only the capsule is left.

The gelatinized grains are as much swollen and have as thin and no more distorted capsules than in *N. princess mary*. The grains are also nearly always completely gelatinized before they are dissolved.

In this reaction *N. cresset* shows qualitatively a somewhat closer relationship to *N. princess mary* than to *N. poeticus poetarum.*

The reaction with *pyrogallic acid* begins in 2 minutes. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 16 per cent of the total starch in 15 minutes; in about 28 per cent of the grains and 69 per cent of the total starch in 30 minutes; in about 37 per cent of the grains and 74 per cent of the total starch in 45 minutes; and in about 39 per cent of the grains and 81 per cent of the total starch in 60 minutes. (Chart D 301.)

The hilum and lamellæ are as distinct as in *N. princess mary*. Gelatinization begins at the hilum, and proceeds according to the two methods which are described under both parents as being in general the same, and a greater number of grains follows the first method than in either parent, showing in this respect that *N. cresset* more closely resembles *N. princess mary* than *N. poeticus poetarum*. A few follow the second method, and these react as do the grains of *N. poeticus poetarum*. The gelatinized grains are as much swollen, have rather thick capsules, and are as much distorted as in *N. princess mary*. In this reaction *N. cresset* shows qualitatively a closer relationship to *N. princess mary* than to *N. poeticus poetarum.*

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 3 per cent of the grains and 22 per cent of the total starch in 5 minutes; in about 24 per cent of the grains and 67 per cent of the total starch in 15 minutes; in about 35 per cent of the grains and 75 per cent of the total starch in 30 minutes; in about 40 per cent of the grains and 77 per cent of the total starch in 45 minutes; and in about 43 per cent of the grains and 80 per cent of the total starch in 60 minutes. (Chart D 303.)

The hilum and lamellæ are as distinct as in *N. princess mary*. Gelatinization begins at the hilum, and proceeds according to two methods as in the parents, and a greater number of grains follows the first method described than in *N. princess mary* or *N. poeticus poetarum*, which is an accentuation of a characteristic of *N. princess mary*. A few follow the second method, and these react as do the grains of *N. poeticus poetarum*, but

not as do similar grains of *N. princess mary*. The gelatinized grains are much swollen and have as thick capsules and are as much distorted as in *N. princess mary*. In this reaction *N. cresset* shows qualitatively a closer relationship to *N. princess mary* than to *N. poeticus poetarum*.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 80 per cent of the entire number of grains and 98 per cent of the total starch in 2 minutes; and about 96 per cent of the grains and 99 per cent of the total starch in 5 minutes. (Chart D 304.)

The hilum is distinct and a bubble is formed there in the majority of the grains, more often than in either parent, but in this respect more closely resembling *N. princess mary*. The lamellæ are not so often moderately distinct as in either parent. Gelatinization begins at the hilum and progresses according to the two methods described as in general the same under both parents. The methods as a rule are the same as those of *N. princess mary*, but in some grains they are the same as those of *N. poeticus poetarum*. The gelatinized grains are as much swollen, have thinner capsules, and are as much distorted as in *N. princess mary*.

In this reaction *N. cresset* shows qualitatively a somewhat closer relationship to *N. princess mary* than to *N. poeticus poetarum*.

18. Starches of Narcissus abscissus, N. poeticus poetarum, and N. will scarlet.

Starch of *N. poeticus poetarum* is described on pp. 519 to 522.

N. abscissus (Seed Parent).

(Plate 12, fig. 67; Charts D 305 to D 310.)

Histologic Properties.

In *form* the grains are usually simple and isolated, but there are moderate numbers of both compound grains and aggregates. The compound grains belong to the following two types, which are placed in the order of their frequency of occurrence: (1) 2, 3, or 4 very small grains, each composed of a hilum and 1 or 2 lamellæ, all inclosed in 3 or 4 common secondary lamellæ; (2) 3 or 4 hila embedded in an amorphous-appearing mass of starch, the whole surrounded by 1 or 2 secondary lamellæ. The aggregates consist of 2, 3, or 4 simple grains arranged linearly or in an irregular pyramidal group. A small majority of the grains show clearly both primary and secondary starch formations. The grains are usually irregular in form and the irregularities are due to the following causes: (1) Small and irregular elevations and depressions in the surface and margin; (2) small pointed and large rounded protuberances from the margin at various points; (3) irregularly placed pressure facets on the sides and distal end; (4) deviation of the transverse axis, usually near the middle with consequent bending of the grain. The conspicuous forms are ovoid, lenticular, plano-convex, irregularly quadrilateral, and triangular. The additional forms are elliptical, broad reniform, nearly round. The grains are not flattened.

The *hilum*, if not fissured, is a distinct round or, rarely, lenticular spot. It is usually very deeply and extensively fissured, and the fissures have the following forms: (1) A single straight, horizontal or longitudinal line which is often somewhat branched; (2) cruciate, T-, Y-, or V-shaped; (3) an irregularly stellate group of fissures. The hilum sometimes centric, but in the majority of the grains it is eccentric from 0.43 to 0.3, usually 0.38, of the longitudinal axis.

The *lamellæ* are moderately distinct, continuous, rather fine rings which are more distinct near the hilum than near the margin. They have in general the form of the outline of the grain, but only near the margin do they follow the contour closely. The number counted on the larger grains varies from 6 to 14, usually 10.

In size the grains vary from the smaller which are 4 by 4μ, to the larger broad forms which are 26 by 40μ, and, rarely, the larger elongated forms, which are 40 by 28μ, in length and breadth. The common sizes are 20 by 24μ, 20 by 28μ, and 24 by 20μ.

Comparison of the *histologic characteristics* between *N. poeticus poetarum* and *N. abscissus* shows:

There are not so many aggregates and compound grains as in *N. abscissus*, and the compound grains belong to the following types, the first two of which are not seen in *N. abscissus:* (1) 2 small grains surrounded by 4 or 5 secondary lamellæ; (2) a large grain to which a small grain has become adherent and both inclosed in 2 or 3 common secondary lamellæ; (3) a number of hila in an amorphous-looking mass which is surrounded by 1 or 2 secondary lamellæ. The aggregates rarely consist of more than 2 grains, but sometimes 3 grains are seen linearly arranged. The grains are somewhat less irregular, and the irregularities are due to the same causes as in *N. abscissus*, with the exception of that owing to deviation of the axis of the grain. The simple grains somewhat less frequently show primary and secondary starch formations. There is not much variation in the types of forms in the two starches.

The *hilum* when not fissured is as distinct as in *N. abscissus*, and is not quite so often but somewhat more deeply and more extensively fissured. The fissures more frequently have a cruciate, Y-, or T-shape, but otherwise resemble closely those of the grains of *N. abscissus*. The degree of eccentricity is the same.

The *lamellæ* in some grains are more distinct, and are coarse rather than fine as in *N. abscissus;* they have the same arrangement.

In *size* the grains are distinctly larger and have but few forms whose longitudinal axis is much longer than the transverse axis. The common sizes are 32 by 30μ, and 30 by 34μ.

Polariscopic Properties.

The *figure* is usually not very distinct nor well defined. The lines cross at angles of widely varying size, and are often bent and sometimes bisected. There are a number of multiple figures and some with 5 or 6 lines instead of 4. The figure has sometimes the form of a conjugate hyperbola, or of a long line bisected at both ends.

The *degree of polarization* varies from low to high (value 43); there are very few grains in which the degree of polarization is high; commonly it is moderate, and sometimes low. There is usually considerable variation in a given aspect of an individual grain.

With *selenite* the quadrants are not clear-cut, and they are unequal in size and often irregular in shape. The colors are usually not pure, and there are few which have a greenish tinge.

Comparison of the *polariscopic properties* between *N. poeticus poetarum* and *N. abscissus* shows:

The figure is somewhat more distinct and well defined. The lines cross at angles whose size is as variable, and are as often bent and bisected. The figure is as often multiple and there are as many figures which have the forms of a conjugate hyperbola, or a long line bisected at both ends.

The *degree of polarization* is somewhat less (value 40), as there are fewer grains with a moderate and more with a low degree of polarization. There is the same amount of variation in a given aspect of an individual grain.

With *selenite* the quadrants are more often clean-cut, but they are as unequal in size and as irregular in shape. The colors are not pure and there are fewer grains which have a greenish tinge.

Iodine Reactions.

With 0.125 per cent Lugol's solution the grains all color a light to moderate violet tinged with blue (value 40) and the color deepens with moderate rapidity, assuming more of a bluish tint until it becomes very deep. With 0.125 per cent Lugol's solution the grains all color a light violet, and the color deepens with moderate rapidity, assuming a distinct bluish tint, until it is deep. After heating in water until all the grains are gelatinized and then adding a 2 per cent Lugol's solution, the gelatinized *grains* all color a moderate to deep indigo, and the *solution* a moderate indigo. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution the *grain-residues* all color a light or a light to moderate indigo, the *capsules* a red or reddish violet, and the *solution* a very deep indigo.

Comparison of the *iodine reactions* between *N. poeticus poetarum* and *N. abscissus* shows:

With 0.25 per cent Lugol's solution the grains color somewhat more than in *N. abscissus* (value 45), and so also with 0.125 per cent Lugol's solution. After heating in water until the grains are gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized grains color somewhat less and the solution more than in *N. abscissus*. After boiling the preparation for 2 minutes and then treating with an excess of a 2 per cent Lugol's solution the grain-residues are less and the solution more deeply colored than in *N. abscissus*.

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes they are light to moderately colored (value 33). Some grains are more stained than others, but there is no difference in the depth of color in different parts of the individual grains.

With *safranin* the grains all color very lightly at once, and in 30 minutes they are moderately colored (value 47), more than with gentian violet. Some grains are more stained than others, but there is no difference in the depth of color in different parts of the individual grains.

Comparison of the *aniline reactions* between *N. poeticus* and *N. abscissus* shows:

With *gentian violet* the grains are colored somewhat more (value 35) and there is no variation in color in the different grains.

With *safranin* they are colored somewhat more (value 50) and there is no variation in color in the different grains. There is very little difference to be noted between the two starches in the reactions with aniline stains.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 69.5° to 71° C., and that of all the grains is 73° to 74.8° C., mean 73.9° C.

Comparison of the *temperature reactions* between *N. poeticus poetarum* and *N. abscissus* shows:

The temperature of gelatinization is somewhat lower than that of *N. abscissus*, 71° to 73° C., mean 72° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 4 per cent of the total starch in 15 minutes; in about 8 per cent of the grains and 11 per cent of the total starch in 30 minutes; in about 15 per cent of the grains and 17 per cent of the total starch in 45 minutes; and in about 16 per cent of the grains and 18 per cent of the total starch in 60 minutes. (Chart D 305.)

The hilum is not distinct unless a bubble is formed there, and a large bubble develops in a majority of the grains. The lamellæ are not visible at any time during the reaction. The grains become more refractive after the addition of the reagent, and the first part to show this change is a rather narrow band of material about the margin. Gelatinization begins at the distal end or just to one side of the distal end and proceeds according to three methods. In the first, which is seen in the majority of the grains, the proximal end gelatinizes soon after the distal end and gelatinization progresses from both ends toward the portion of the grain just distal to the hilum, which is the most resistant part of the grain and which at the end of the reaction is split lengthwise by a fissure and separated into two pieces which gelatinize separately. In the second method, which is seen in a moderate number of grains, gelatinization begins at the distal margin and proceeds toward the hilum with serial separation of the lamellæ until the hilum is reached. The hilum swells suddenly and the bubble, if present, swells, then shrinks, and finally disappears, and the proximal starch becomes more hyaline in appearance and then is rapidly gelatinized. In the third method, which is also seen in a moderate number of grains, the marginal material is all gelatinized and the inner portion gradually grows more refractive, then is invaded by irregular fissures and small pieces broken off which float off and are gelatinized. When the hilum is reached it swells suddenly and the portion immediately surrounding it, which is the most resistant part of the grain, is rapidly gelatinized. The gelatinized grains are much swollen and have thin capsules. They are greatly distorted and do not bear any resemblance to the form of the untreated grain.

Comparison of the *chloral-hydrate* reactions between *N. poeticus poetarum* and *N. abscissus* shows:

A bubble is much less frequently formed at the hilum, and the lamellæ are more often moderately distinct than in *N. abscissus*. The grains become less refractive after the addition of the reagent and the band of material around the margin, which is the first part of the grain to show this change, is narrower than in *N. abscissus*. Gelatinization proceeds according to two methods neither of which resembles closely the three methods noted in *N. abscissus*. In the first method, which is somewhat similar to the third method of *N. abscissus*, the marginal starch is gelatinized nearly to the proximal end on both sides and then proceeds inward, preceded by fissuring of the ungelatinized portion and splitting off of particles of ungelatinized material. In the second method gelatinization begins at several points on the margin and proceeds from each of these points, forming deep, cup-shaped hollows which finally coalesce before the hilum and proximal end are reached. The gelatinized grains are as much swollen and have thinner capsules and are more distorted than those of *N. abscissus*.

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 26 per cent of the total starch in 15 minutes; in about 12 per cent of the grains and 81 per cent of the total starch in 30 minutes; in about 46 per cent of the grains and 95 per cent of the total starch in 45 minutes; and in about 62 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 306.) (See footnote, page 516.)

The hilum is distinct, and the lamellæ are distinct in all the grains. Gelatinization begins at the hilum and progresses according to two methods. In the first, which is seen in a great majority of the grains, the primary starch is divided by fissures or cracks into a number of particles. In most of the grains these particles are again divided until the central part of the interior of the large grain appears filled with a fine granular mass which is the first part to be gelatinized. The secondary starch meanwhile is coarsely striated, and as the finely granular primary starch and the less resistant part of the secondary starch are gelatinized and the grain swells, the more resistant material forms a coarsely striated marginal band which is thinner in some places than in others. This band gradually grows thinner and more nearly transparent and is eventually dissolved at the points where it is thinnest. In other grains the primary starch is divided into rather large fragments which are very resistant and are scattered around the inner border of the marginal band formed of the secondary starch and remain there until the capsule is dissolved in one or two places and then flow out into the reagent and are dissolved. In the second method, which is seen in only a few of the grains, two furrows or actual fissures extend from either side of the hilum nearly to the margin, and distal to these furrows or fissures are a number of other branching fissures which radiate out from the hilum on either side like a bundle of wheat. The material between the hilum, the furrows, and the margin becomes finely granular, except a narrow band at the margin, and is slowly gelatinized, while the radiating fissures before described slowly widen and branch and finally disappear. The proximal starch meanwhile is coarsely striated, and with the thin portion of material already described, which is around the rest of the margin, forms a striated band which slowly grows thinner and then is dissolved in 1 or 2 places. The contents flow out and are dissolved and the marginal portion slowly dissolves also, the proximal portion being the most resistant. The grains are always dissolved before gelatinization is complete.

Comparison of the *chromic-acid* reactions between *N. poeticus poetarum* and *N. abscissus* shows:

The hilum is as distinct but the lamellæ are not so distinct as in *N. abscissus*. Gelatinization follows two methods, one of which is very similar to the one described under *N. abscissus*. In the first, which resembles that described for a small minority of the grains of *N. abscissus*, the main points of difference noted are that the fissures which divide the grain distal to the preliminary furrows from either side of the hilum are finer and more numerous, and that the whole area between the furrows and the margin becomes finely granular and is gelatinized, instead of a small band of material at the margin remaining ungelatinized, as in *N. abscissus*. In the second method there are several differences to be noted between *N. abscissus* and *N. poeticus poetarum*. There is no apparent distinction between primary and secondary starch, but several fissures extend longitudinally from the hilum to the distal margin, and this part of the grain is gelatinized first and then the portion at the proximal end and sides nearby is striated and slowly gelatinized. The grains are frequently dissolved before gelatinization is complete, but in some grains gelatinization is complete and the gelatinized grains are much swollen, have thin capsules, and are considerably distorted.

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 23 per cent of the total starch in 5 minutes; in about 25 per cent of the grains and 66 per cent of the total starch in 15 minutes; in about 46 per cent of the grains and 79 per cent of the total starch in 30 minutes; in about 62 per cent of the grains and 88 per cent of the total starch in 45 minutes; and in about 71 per cent of the grains and 92 per cent of total starch in 60 minutes. (Charts D 307, D 308.)

The hilum is distinct; the lamellæ are moderately distinct, but do not remain so during the reaction. Gelatinization begins at the hilum and progresses according to two methods. In the first, which is seen in the great majority of the grains, the primary starch is split lengthwise into two pieces, which are in turn each divided into two or three pieces. The secondary starch which surrounds the primary starch is meanwhile marked by rather fine striæ. As the less resistant material of both primary and secondary starch is gelatinized, causing swelling of the whole grain, the more resistant part of the secondary starch forms a finely striated marginal band, around the inner border of which the subdivided particles of the primary starch are scattered. The marginal band becomes more coarsely striated and develops a feathery or spicular inner border and then gradually grows thinner and more refractive and is finally gelatinized. The particles of the primary starch are very resistant and remain for some time after the rest of the grain has been gelatinized. In the second method two furrows extend trans-

versely from either side of the hilum to the margin and the starch included between them and the hilum and the margin is divided by rather fine striæ and then becomes finely granular in appearance, except a narrow band at the margin, and is slowly gelatinized, with considerable swelling. The more resistant portion at the proximal end and sides nearby is rather coarsely striated and then by conjunction with the thin band of resistant deposit around the rest of the margin forms a marginal band, which is very resistant but grows gradually thinner and more nearly transparent until it is gelatinized, leaving only the thin capsule. The gelatinized grains are much swollen, have rather thin capsules, and are somewhat distorted.

Comparison of the *pyrogallic-acid* reactions between *N. poeticus poetarum* and *N. abscissus* shows:

The hilum and lamellæ are not so distinct as in *N. abscissus.* Gelatinization follows two methods of procedure, as in *N. abscissus,* but the majority follow the second method described and show distinct and irregular fissuring in the distal material preceding gelatinization. A moderately large minority follow the first method described, except that the primary material is split into finer particles, while the striæ in the secondary starch are finer. The gelatinized grains are more swollen, have thinner capsules, and are usually considerably more distorted.

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 2 per cent of the grains and 33 per cent of the total starch in 5 minutes; in about 28 per cent of the grains and 66 per cent of the total starch in 15 minutes; in about 39 per cent of the grains and 73 per cent of the total starch in 30 minutes; in about 48 per cent of the grains and 80 per cent of the total starch in 45 minutes; and in about 56 per cent of the grains and 86 per cent of the total starch in 60 minutes. (Charts D 303 and D 309.)

The hilum is distinct and no bubbles are formed there. The lamellæ are moderately distinct, but do not remain so long after the reaction starts. Gelatinization begins at the hilum and follows two methods of procedure. In the first, which occurs in the great majority of the grains, the portion immediately surrounding the hilum, which probably represents the primary formation of starch, is split lengthwise into two pieces, which are then each subdivided into two or three parts. The portion surrounding this primary starch, which probably represents a secondary starch formation, becomes divided by rather coarse striæ. As the less resistant starch of both primary and secondary starch is gelatinized, causing swelling of the whole grain, the more resistant secondary starch forms a coarsely striated and lamellated marginal band, around the inner border of which, at the proximal end, the subdivided particles of the primary starch are arranged. The marginal band soon loses its lamellar appearance and is divided into two parts, a single row of granules at the margin, and within this a more refractive row of spicules whose free ends give a feathery appearance to the inner border. The inner part is gelatinized first and the outer granular layer remains for a long time, but gradually grows thinner and finally disappears. The particles of the primary starch are divided and subdivided until they are formed into a number of rather coarse granules which are very resistant and remain after the rest of the grain has been gelatinized, in some cases not being gelatinized at the end of an hour. In some grains the primary starch is divided into two pieces or is not divided at all, and remains ungelatinized after the rest of the grain is gelatinized. In the second method 2 furrows or fissures extend horizontally from the hilum to the margin, and the material included between them, and the hilum and the margin, is first divided by striæ and divided irregularly by refractive fissures, except a thin band of starch at the margin, and then gelatinized more rapidly from the hilum outward, with considerable irregular swelling. The more resistant material at the proximal end becomes rather coarsely striated, and as the grain swells it is pushed to the margin at the proximal end and sides nearby, where it forms a striated band which unites with the resistant starch around the rest of the margin and in which the lamellar structure is at first dimly visible but is later obscured and the substance of the band is slowly gelatinized.

The gelatinized grains are much swollen and have rather thin capsules; they are somewhat distorted and do not have much resemblance to the forms of the untreated grains.

Comparison of the *nitric-acid* reactions between *N. poeticus poetarum* and *N. abscissus* shows:

The hilum and lamellæ are not so distinct as in *N. abscissus.* Gelatinization follows two types of procedure, as in *N. abscissus,* but the majority follow the second type described and show more distinct and more persistent lamellation and less irregular fissuring than do similar grains of *N. abscissus.* A moderately large minority follows in the main the first method described, the differences noted being that the primary deposit is split into more and smaller particles, which are, however, just as resistant as those of *N. abscissus,* while the striæ in the secondary starch are not so coarse and the lamellæ are more distinct and somewhat more persistent, and the marginal band is not divided into an outer granular and an inner spicular part. The gelatinized grains are more swollen and have thinner capsules and are, usually, considerably more distorted than in *N. abscissus.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 90 per cent of the entire number of grains and 99 per cent of the total starch in 2 minutes, and in more than 99 per cent of the grains and total starch in 5 minutes. (Chart D 310.)

The hilum becomes distinct, attended by the formation of a bubble in the great majority of the grains. The lamellæ are very distinct or moderately distinct. Gelatinization begins at the hilum and progresses according to two methods. In the great majority of the grains the portion immediately surrounding the hilum is split by fissures into several parts, which in most of the grains begins to gelatinize and swell. At the same time the secondary deposit surrounding this is divided by striæ and the inner portion becomes granular and then is gelatinized and the outer, more resistant portion forms a homogeneous-looking, refractive marginal band which grows thinner and more nearly transparent until it is also gelatinized. The process in the primary part of the grain is the same as this, but is slower. In some grains the primary grain does not begin to gelatinize until the secondary starch is completely gelatinized, and then

either remains intact or is broken into three or four pieces and then gelatinized. In the second method, which is seen in a few grains, 2 furrows, or in some cases actual fissures, extend horizontally from either side of the hilum to the margin and the material included between them, the hilum and the margin is divided by concentric fissures into portions of varying size, and these portions are gelatinized from without inward, the portion just distal to the hilum being the last to be gelatinized. The material at the proximal end and sides nearby is pushed to the margin, and these remain as a homogeneous-looking, thick, refractive band which is gelatinized rather slowly after the rest of the grain has been gelatinized. The gelatinized grains are much swollen, have rather thick capsules, and are much distorted.

Comparison of the *sulphuric-acid* reactions between *N. poeticus poetarum* and *N. abscissus* shows:

A bubble is not formed at the hilum nearly so frequently and the lamellæ are not so distinct as in *N. abscissus.* Gelatinization progresses according to two methods, which are very nearly the same as those already described under *N. abscissus.* The first, which is seen in the great majority of the grains, is that which is described as occurring in only a few grains of *N. abscissus,* and the main points of difference recorded are that following the preliminary separation by concentric fissures which occurs in both starches, this starch melts down into a finely granular mass and is gelatinized from within outward apparently, instead of remaining more or less distinctly fissured and being gelatinized from without inward, as in *N. abscissus.* In the second method, which is seen in but few grains and which is that described for the great majority of grains of *N. abscissus,* the main points of difference noted are that the primary starch is divided always into several pieces and is always very resistant, while the secondary starch is divided by concentric fissures into portions of varying size as a preliminary to gelatinization. The gelatinized grains are as much swollen, have thinner capsules, and are as much distorted as in *N. abscissus.*

Narcissus will scarlet (Hybrid).

(Plate 12, fig. 69; Charts D 305 to D 310.)

Histologic Properties.

In *form* the grains are usually simple and isolated, and there are somewhat fewer compound grains and aggregates than in *N. abscissus,* but more than in *N. poeticus poetarum.* The compound grains belong to the two types described under *N. abscissus,* and the aggregates are also of the same types as in that starch. There are comparatively few grains in which primary and secondary starch formations can be clearly seen, and in this the hybrid is somewhat closer to *N. poeticus poetarum* than to *N. abscissus.* The grains are as irregular as in *N. abscissus,* and the irregularities are due to the same causes enumerated in that starch. The conspicuous forms are plano-convex, ovoid, lenticular, and broad reniform. The additional forms are triangular, irregularly quadrilateral, and elliptical.

In form *N. will scarlet* shows a somewhat closer relationship to *N. abscissus* than to *N. poeticus poetarum.*

The *hilum* is as distinct as in both parents, and is not so often nor so deeply and extensively fissured as in either parent, and in this it shows a closer relationship to *N. abscissus.* The fissures have the same forms in the same order of frequency of occurrence as in *N. abscissus.* The hilum is sometimes centric, but in the majority of the grains it is eccentric from 0.42 to 0.29, usually 0.37, of the longitudinal axis.

In the character of the hilum *N. will scarlet* shows a somewhat closer relationship to *N. abscissus* than to *N. poeticus poetarum.* The degree of eccentricity in the three starches is practically the same.

The *lamellæ* are in some grains very distinct and in others moderately distinct, more than in either parent, and in this respect showing a closer relationship to *N. abscissus* than to *N. poeticus poetarum.* They are rather fine continuous rings which follow the form of the outline of the grain. The number counted on the larger grains varies from 8 to 14, usually 12.

In the character of the lamellæ *N. will scarlet* shows a closer relationship to *N. abscissus* than to *N. poeticus poetarum.*

In *size* the grains vary from the smaller which are 4 by 4μ, to the larger which are 38 by 44μ and 40 by 42μ. The common sizes are 34 by 38μ and 32 by 34μ. The large grains of *N. will scarlet* are the same as in *N. abscissus,* but the common-sized grains are closer the size of those of *N. poeticus poetarum.*

Polariscopic Properties.

The *figure* as in *N. abscissus* is not very distinct and is not often well defined. The lines cross at angles of widely varying degree, and are often bent and sometimes bisected, as in the parents. There are a number of multiple figures and some of the figures have 5 and 6 lines instead of 4. There are also the same number of figures which have the forms of a conjugate hyperbola, or a long line bisected at both ends, as in the parents.

The *degree of polarization* varies from low to high (value 43), the same as in *N. abscissus* and more than in *N. poeticus poetarum.* There is the same amount of variation in a given aspect of an individual grain as in the parents.

With *selenite* the quadrants as in *N. abscissus* are not well defined, and are unequal in size and irregular in shape. The colors are not pure and there are few grains which have a greenish tinge.

In the degree of polarization, the character of the figure, and the appearance with selenite, *N. will scarlet* shows a closer relationship to *N. abscissus* than to *N. poeticus poetarum.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a light to moderate violet tinged with blue (value 45), the same as in *N. poeticus poetarum,* and more than in *N. abscissus.* With 0.125 per cent Lugol's solution the grains all color a light violet, the same as in *N. poeticus poetarum* and more than in *N. abscissus.* After heating in water until all the grains are gelatinized and then adding a 2 per cent Lugol's solution the gelatinized *grains* all color a moderate indigo, the same as in *N. poeticus poetarum,* and the *solution* a deep indigo, the same as in *N. poeticus poetarum.* If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution the *grain-residues* color a light to

moderate indigo, the *capsules* a red or a reddish violet, and the *solution* a very deep indigo-blue, as in *N. poeticus poetarum.*

Qualitatively and quantitatively the reaction with iodine shows a closer relationship to *N. poeticus poetarum* than to *N. abscissus.*

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes they are light to moderately colored (value 37), more than in either parent but nearer to *N. poeticus poetarum.*

With *safranin* the grains all color very lightly at once, and in 30 minutes they are moderately colored (value 53), more than either parent, but closer to *N. poeticus poetarum.*

In the reaction with aniline stains, *N. will scarlet* shows a closer relationship to *N. poeticus poetarum* than to *N. abscissus.*

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 69.8° to 71.9° C., and of all is 72° to 74° C., mean 73° C.

The temperature of gelatinization of *N. will scarlet* is somewhat closer to that of *N. abscissus,* though the mean value is practically midway between those of *N. abscissus* and *N. poeticus poetarum.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 2 minutes. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about the same percentage of the grains and 3 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 8 per cent of the total starch in 30 minutes; in about 12 per cent of the grains and 16 per cent of the total starch in 45 minutes; and little further advance in 60 minutes. (Chart D 305.)

A bubble is not so frequently formed at the hilum as in *N. abscissus,* but much more frequently than in *N. poeticus poetarum.* The lamellæ, as in *N. abscissus,* are not visible at any time during the reaction. The grains after the addition of the reagent become as refractive as in *N. abscissus.* Gelatinization, as in the parents, begins at various points on the margin, usually the distal margin, and proceeds according to three methods which very closely resemble the three described under *N. abscissus.* There are equal numbers in which may be seen the first and third methods, and the main differences noted in these grains from those of *N. abscissus* are less fissuring and separation of small particles, and somewhat less generally a splitting of the portion just distal to the hilum, which is often the most resistant part of the grain. The third method is seen in few grains and does not appear to differ from that described under *N. abscissus.* The gelatinized grains are as much swollen, have as thin capsules, and are as distorted as those of *N. abscissus.*

In this reaction *N. will scarlet* shows qualitatively a much closer relationship to *N. abscissus* than to *N. poeticus poetarum.*

The reaction with *chromic acid* begins in half a minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 49 per cent of the total starch in 15 minutes; in about 22 per cent of the grains and 83 per cent of the total starch in 30 minutes; in about 46 per cent of the entire number of grains and 97 per cent of the total starch in 45 minutes; and in about 66 per cent of the grains and 99 per cent of the total starch in 60 minutes. (Chart D 306.) (See footnote, page 516.)

The hilum and lamellæ are as distinct as in *N. abscissus.* Gelatinization begins at the hilum and progresses according to the two methods described in *N. abscissus.* The first method, which occurs in the majority of grains of *N. abscissus,* occurs also in a majority (but not in so large a majority) of grains of the hybrid. The second method is seen in more grains, but there is no difference to be noted in the method itself.

Some of the grains are gelatinized before they are dissolved, but fewer than in *N. poeticus poetarum.* They are much swollen, have thicker capsules, and are as much distorted as in *N. poeticus poetarum.*

In this reaction *N. will scarlet* shows qualitatively a closer relationship to *N. abscissus* than to *N. poeticus poetarum.*

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 8 per cent of the grains and 26 per cent of the total starch in 15 minutes; in about 30 per cent of the grains and 73 per cent of the total starch in 30 minutes; in about 49 per cent of the grains and 81 per cent of the total starch in 45 minutes; and in about 51 per cent of the grains and 86 per cent of the total starch in 60 minutes. (Chart D 307.)

The hilum and lamellæ are as distinct as in *N. poeticus poetarum.* Gelatinization begins at the hilum and follows the two methods described in both parents. A smaller majority than in *N. abscissus* follows the method described for a majority of the grains of that starch, and a moderate minority follows the second method, some of the grains as do those of *N. abscissus,* and some as do those of *N. poeticus poetarum.* The gelatinized grains are as much swollen, have as thin capsules, and are as much distorted as in *N. abscissus.* In this reaction *N. will scarlet* shows qualitatively a somewhat closer relationship to *N. abscissus* than to *N. poeticus poetarum.*

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 61 per cent of the total starch in 5 minutes; in about 30 per cent of the grains and 78 per cent of the total starch in 15 minutes; in about 35 per cent of the grains and 82 per cent of the total starch in 30 minutes; in about 43 per cent of the grains and 87 per cent of the total starch in 45 minutes; and in about 52 per cent of the grains and 91 per cent of the total starch in 60 minutes. (Chart D 309.)

The hilum and lamellæ are as distinct as in *N. abscissus.* Gelatinization begins at the hilum and follows the two methods described under both parents. The method described for a great majority of the grains of *N. abscissus* is seen in a smaller majority of the hybrid, the main differences noted being that the striation

of the secondary deposit is not so coarse and the lamellation more distinct and persistent, which shows the influence of *N. poeticus poetarum*. A moderate-sized minority of the grains follows the second method, the differences noted being that the striæ at the proximal end are not so coarse and the lamellation more distinct and more persistent. The gelatinized grains are as much swollen, have as thin capsules, and are as much distorted as in *N. abscissus*.

In this reaction *N. will scarlet* shows qualitatively a closer relationship to *N. abscissus* than to *N. poeticus poetarum*.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 92 per cent of the entire number of grains and 98 per cent of the total starch in 2 minutes, and in about 97 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 310.)

The hilum and lamellæ are as distinct as in *N. abscissus* and a bubble is formed at the hilum as frequently as in that starch. Gelatinization begins at the hilum and progresses according to the two methods seen in both parents, and the majority of the grains follow the same method that was described for the majority of the grains of *N. abscissus*, and for only a minority of the grains of *N. poeticus poetarum*, while a small minority follows the second method. The only difference noted in either method was that there was not so much fissuring of the grains. The gelatinized grains are as much swollen, have as thick capsules, and are as distorted as in *N. abscissus*.

In this reaction *N. will scarlet* shows qualitatively a somewhat closer relationship to *N. abscissus* than to *N. poeticus poetarum*.

19. Starches of Narcissus albicans, N. abscissus, and N. bicolor apricot.

Starch of *N. abscissus* is described on pages 554 to 558.

N. albicans (Seed Parent).

(Plates 12 and 13, figs. 70 and 74; Charts D 311 to D 316.)

Histologic Properties.

In *form* the grains are usually simple and isolated, although aggregates and compound grains are of very common occurrence. The aggregates are usually doublets or triplets of equal size, linearly or pyramidally arranged; but there are some consisting of 10 to 12 grains which form an irregular, compact, knobby mass. The compound grains belong to three types: In one there are 2 or 3 component grains, each consisting of a hilum surrounded by 3 or 4 lamellæ, and all the components in turn surrounded by 5 or 6 secondary lamellæ; in the second type there are 2 to 12 component grains, each consisting of a hilum and a distinct lamella, and all surrounded by 1 or 2 secondary lamellæ; in the third type there are, as a rule, 2 or rarely 3 component grains, one of which is a large simple grain, to the side of the distal end of which 1 or 2 small grains have become adherent, and the combination later inclosed by 1 or 2 secondary lamellæ. A number of aggregates consists of one or more simple grains combined with one or more compound grains of the first and second types described. The grains are, as a rule, moderately regular in form, but a majority show some and a moderate number show considerable irregularities, and these irregularities are due to the following causes: (1) Small or, rarely, large rounded protuberances from the proximal end, sides, or distal end; (2) shallow depressions and elevations of the surface and margin of the grain, causing an undulating or wavy outline; (3) deviation of the transverse axis and consequent bending of the grain in the middle or at either end; (4) the greater development of one part of the distal end; (5) 2 indentations, one on either side of, and just below, the proximal apex. There is a moderate number of grains in which a rather small grain has later been surrounded by 3 or 4 lamellæ of a secondary starch which are distinctly separated from the primary lamellæ by a deep furrow, and by the difference in refractivity of the starches. The conspicuous forms are broad, rounded ovoid, narrow pointed ovoid, nearly round, and short elliptical with both ends rounded or with a flattened distal end. There are also plano-convex, triangular with rounded angles, quadrilateral, a few pyriform, and a few lenticular forms. The broad forms are flattened, but the others are not.

The *hilum*, when not fissured, is a not very distinct, small, round or, rarely, lenticular spot. It usually is fissured, however, and the fissures have the following forms: (1) A short, straight line placed transversely, obliquely, or rarely, longitudinally; (2) irregularly V- or Y-shaped; (3) a long, irregularly branching, transverse line; (4) T-shaped or cruciform; (5) flying-bird figure. The hilum is sometimes centric, but in the majority of the grains it is eccentric from 0.46 to 0.25, usually 0.38, of the longitudinal axis.

The *lamellæ* are commonly not very distinct, but some grains show rather fine continuous rings, which usually follow the form of the outline of the grain. The primary grains, which have a secondary deposit of starch surrounding them, do not show lamellation in the primary starch, but do in the secondary deposit. The number of lamellæ counted on some of the large grains varies from 6 to 14, usually 10.

The *size* of the grains varies from the smaller which are 4 by 4μ, to the larger elongated forms which are 40 by 34μ, and the larger broad forms which are 28 by 38μ and 40 by 40μ, in length and breadth. The common sizes are 22 by 26μ, 22 by 22μ, and 22 by 18μ.

Comparison of the *histologic properties* between *N. abscissus* and *N. albicans* shows:

There are not so many compound grains or aggregates. The compound grains belong to two types, which are the same as the first two types described under *N. albicans;* the third type described under that starch is not seen. The aggregates belong to the same types as in *N. albicans*. There are more simple grains in which a rather small primary grain has been surrounded by several secondary layers of starch. The grains are somewhat more irregular in form and the irregularities are due to the same causes, but there are fewer pointed protuberances and more small depressions and elevations of the surface. The forms are somewhat more rounded than those of *N. albicans*.

The *hilum* is more distinct and is not so frequently nor so extensively fissured, but the fissures have the same forms. A cruciate figure is not so often seen, however. The hilum is sometimes more eccentric, but usually the degree of eccentricity is the same as in *N. albicans*.

The *lamellæ* are more distinct and finer than in *N. albicans.* The number can be determined on most of the grains and is usually 10.

In *size* the grains are very nearly the same, but as a rule slightly larger. The common sizes are 20 by 24μ, 20 by 28μ, and 24 by 20μ.

Polariscopic Properties.

The *figure* is moderately to well defined. The lines cross at right angles or at acute angles which do not vary greatly in size. They are not often bent or bisected. There are a few figures which are not crosses, but have the form of an hyperbola or of a long line bisected at both ends.

The *degree of polarization* varies from low to high (value 37), and the greater number of grains shows a low or a moderate degree of polarization. There is also considerable variation in a given aspect of the same grain.

With *selenite* the quadrants are moderately well defined, unequal in size, and usually regular in shape. The colors are usually not pure, and very rarely is one seen with a greenish tinge.

Comparison of the *polariscopic properties* between *N. abscissus* and *N. albicans* shows:

The *figure* is as distinct, but is not so well defined. The lines cross at angles of widely varying size and are often bent. There are more figures with the form of a conjugate hyperbola, or a long line bisected at both ends than in *N. albicans.*

The *degree of polarization* is more (value 43) and there are more grains in which the degree of polarization is moderately high and high. There is less variation in a given aspect of the same grain.

With *selenite* the quadrants are not so clean-cut and are more irregular in shape. The colors are more often pure and there are more grains which have a greenish tinge.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate violet tinged with blue (value 55), and the color deepens with moderate rapidity until they are all very deeply colored and bluer in tint. With 0.125 per cent Lugol's solution the grains all color a light violet and the color deepens with moderate rapidity until the grains are all deeply colored and have more of a bluish tint. After heating in water until the grains are all gelatinized and then treating with a 2 per cent Lugol's solution the gelatinized *grains* all color a moderate indigo and the *solution* a deep indigo. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the *grain-residues* all color a light indigo, the *capsules* a red or reddish violet, and the *solution* a very deep indigo.

Comparison of the *iodine reactions* between *N. abscissus* and *N. albicans* shows:

With 0.25 per cent Lugol's solution the grains color less (value 40) and so also with 0.125 Lugol's solution. After heating in water until the grains are all gelatinized and treating with a 2 per cent Lugol's solution, the grains are more and the solution less colored. After boiling for 2 minutes and treating with an excess of a 2 per cent Lugol's solution, the grain residues are more colored, the capsules and solution the same as in *N. albicans.*

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes they are light to moderately colored (value 40). The grains are all equally colored and there is no variation in color in different parts of the same grain.

With *safranin* the grains all color very lightly at once, and in 30 minutes they are moderately colored (value 50), more than with gentian violet. The grains are all equally colored and there is no variation in color in different parts of the same grain.

Comparison of the *aniline reactions* between *N. abscissus* and *N. albicans* shows:

With gentian violet the grains are more lightly colored (value 33), with safranin they are somewhat less deeply colored (value 47), but the difference is not so great as with gentian violet.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 70.2° to 72° C., and of all is 73° to 75° C., mean 74° C.

Comparison of the *temperature reactions* between *N. abscissus* and *N. albicans* shows:

The temperature of gelatinization is very nearly the same as in *N. albicans*—73° to 74.8° C., mean 73.9° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in a few grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 11 per cent of the grains and 14 per cent of the total starch in 15 minutes; in about 28 per cent of the grains and 31 per cent of the total starch in 30 minutes; in about 37 per cent of the grains and 40 per cent of the total starch in 45 minutes; and in about 40 per cent of the grains and 43 per cent of the total starch in 60 minutes. (Chart D 311.)

The hilum becomes distinct, accompanied by the formation of a small bubble in a great majority of the grains. The lamellæ are usually not visible, and when visible they are not very distinct. The grains become more refractive after the addition of the reagent, and the first portion of the grain to be so affected is a rather broad band of the marginal starch. Gelatinization begins at various discrete points on the margin at the distal end or side, and progresses first from point to point around the margin and then inward, preceded by fissuring of the ungelatinized starch and separation and subsequent gelatinization of rather large particles, so that the ungelatinized material soon assumes an angular rather than rounded form. Gelatinization proceeds more rapidly along the margin than in the interior, so that the marginal deposit even at the proximal end, is gelatinized before the portion just surrounding and immediately distal to the hilum, which is the last to be gelatinized. In the elongated form gelatinization begins at the distal margin and proceeds smoothly towards the hilum, which swells suddenly when it is reached. The proximal end is the last part to be gelatinized, but is gelatinized rapidly after the hilum swells.

The gelatinized grains are much swollen and have rather thick capsules, they are very much distorted and do not retain any resemblance to the form of the untreated grain.

Comparison of the *chloral-hydrate* reactions between *N. abscissus* and *N. albicans* shows:

A bubble is not formed at the hilum in so many grains as in *N. albicans*, and the lamellæ are not visible in any of the grains. The marginal material, which first shows an increased refractivity after the addition of the reagent, is in a band which is not so broad as in *N. albicans*. Gelatinization progresses according to three methods instead of two, as in *N. albicans*. In the first, which is seen in the majority of the grains and which was not observed in *N. albicans*, gelatinization begins first at the distal end, then at the proximal and progresses from these two points, the portion of the grain just distal to the hilum being the last to be gelatinized. In the second method, which somewhat resembles the second method described under *N. albicans*, gelatinization begins at the distal margin and proceeds toward the hilum, accompanied by serial separation of groups of lamellæ, which is not seen in *N. albicans*. The proximal end is the last portion gelatinized in such grains. The third method is the same as that described for the majority of the grains of *N. albicans*.

The gelatinized grains are more swollen, have thin instead of thick capsules, and are not so much distorted as in *N. albicans*.

The reaction with *chromic acid* begins in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 11 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 75 per cent of the total starch in 15 minutes; in about 57 per cent of the grains and 98 per cent of the total starch in 30 minutes; in about 95 per cent of the grains and 99 per cent of the total starch in 45 minutes; and in more than 99 per cent of the same in 60 minutes. (Chart D 312.) (See footnote, page 516.)

The hilum becomes distinct, and the lamellæ are distinct in all of the grains. Gelatinization begins at the hilum and progresses according to two methods. In a small majority of the grains the portion immediately surrounding the hilum, which in some grains represents a primary starch formation, but which in others can not be definitely distinguished as such, is divided and subdivided by fissures into a number of rather coarse, distinct granules. Then a sheaf of irregular fissures extends from the hilum toward both the proximal and the distal margin or only toward the distal margin, dividing the material in their path into granules; the rest of the substance of the grain is rather finely striated. The granular material around the hilum begins to gelatinize first, although portions of it are very resistant and remain ungelatinized until the grain is finally dissolved, and then the portion traversed by the sheaf of fissures. The striated portion of the grain is pushed to the margin on either side as the grain swells, where it forms a finely striated band. This becomes thinner and more refractive, and the striæ become coarse as gelatinization progresses; finally the capsule is dissolved at one of the points reached by the fissures from the hilum, and the contents of the grain flow out and are dissolved. In the second type, which is seen in a large minority of the grains, two furrows or fissures proceed transversely or obliquely from the hilum to the margin, and the material included between the hilum and the distal margin is divided by coarse striæ into rows of coarse granules arranged as are the lamellæ in the untreated grain. A narrow band of starch which is not so narrow at the proximal end is not so divided, but is finely striated. The grain begins to gelatinize from the hilum outward and before gelatinization is complete the capsules and the marginal band of starch at the distal margin are dissolved and the contents of the grain flow out of this opening and also are dissolved. The grains are always dissolved before gelatinization is complete.

Comparison of the *chromic-acid* reactions between *N. abscissus* and *N. albicans* shows:

The hilum and lamellæ are as distinct as in *N. albicans*, but the lamellar structure remains visible during a greater part of the reaction than in that starch. Gelatinization progresses according to two methods, and that observed in the great majority of the grains bears very little resemblance to that seen in a small majority of the grains of *N. albicans*. The starch immediately around the hilum or the primary starch is divided by many fissures into particles which are divided and subdivided until the central portion of the interior of the grain is filled with a mass of fine granules. The starch surrounding this portion, which is probably a secondary formation, is coarsely striated, and as the primary starch and the less resistant part of the secondary starch are gelatinized and the grain swells the more resistant part of the secondary starch forms a coarsely striated marginal band which is thinner in some places than in others. This band gradually grows thinner and more nearly transparent, and is eventually dissolved at the points where it is thin. In some grains the primary starch only forms large particles which are very resistant and remain after the rest of the grain is dissolved. The second method, which is seen in only a small number of grains, is very like that noted in a large minority of the grains of *N. albicans*, and the main differences noted are that just distal to the primary furrows or fissures are two sheaves of fine irregular fissures, and the material divided by these fissures is the first to gelatinize. The remainder of the distal starch is not striated, but loses its original structural appearance and becomes a finely granular mass. There is a narrow band of material around the entire margin, as in *N. albicans*, but is coarsely striated, especially at the proximal end. It is dissolved at the distal end of the grains after the starch in the interior is nearly gelatinized and the contents of the grain flow out and are dissolved. The proximal portion is the last to be gelatinized. The grains, as in *N. albicans*, are always dissolved before gelatinization is complete.

The reaction with *pyrogallic acid* begins in 30 seconds. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 25 per cent of the total starch in 5 minutes; in about 31 per cent of the grains and 78 per cent of the total starch in 15 minutes; in about 69 per cent of the grains and 91 per cent of the total starch in 30 minutes; in about 75 per cent of the grains and 95 per cent of the total starch in 45 minutes; and in about 85 per cent of the grains and

97 per cent of the total starch in 60 minutes. (Charts D 313 and D 314.)

The hilum is distinct and a bubble is never formed there. The lamellæ are distinct at first, but later are obscured. Gelatinization begins at the hilum and in the great majority of grains progresses according to but one method. The portion immediately surrounding the hilum is divided into many rather coarse granules and the starch surrounding this is either divided by fine striæ or loses its lamellated appearance and becomes more refractive, especially at a number of scattered discrete points. The hilum swells and the more resistant portion of this latter material forms a thick homogeneous-looking band at the margin, while in the interior of the grain are scattered the granules formed from the deposit around the hilum. The marginal band grows progressively thinner and more nearly transparent until it is all gelatinized and only the thin capsule remains. The granules remain for a long time in the interior of the grain, but finally they too are gelatinized. In a few grains the starch around the hilum is split into three or four pieces which remain clumped together in the middle of the grain and are apparently never completely gelatinized. The gelatinized grains are much swollen, have rather thick capsules, and are somewhat distorted.

Comparison of the *pyrogallic-acid* reactions between *N. abscissus* and *N. albicans* shows:

The hilum and lamellæ are as distinct as in *N. albicans,* and the lamellar structure sometimes persists after gelatinization is far advanced. Gelatinization follows two methods of procedure instead of but one. The majority of the grains follows closely the method described for all the grains of *N. albicans,* the main difference noted being that the starch immediately surrounding the hilum is always broken into two or three pieces and the pieces later subdivided, so that they are smaller than in *N. albicans.* The striæ which mark the rest of the grain are not so fine and are seen in most of the grains, and the marginal band is divided into an outer striated and an inner spicular border. In the second method two furrows or actual fissures extend transversely from either side of the hilum to the margin and the material included between them and the hilum and the margin is divided by rather fine striæ and then becomes finely granular in appearance, except a narrow band at the margin, and is slowly gelatinized. The more resistant portion at the proximal end, in connection with the before-mentioned band around the rest of the margin, forms a complete marginal band which gradually is gelatinized, the proximal end being the last to be gelatinized. The gelatinized grains are as much swollen, have as thin capsules, and are more distorted than in *N. albicans.*

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 33 per cent of the total starch in 5 minutes; in about 39 per cent of the grains and 78 per cent of the total starch in 15 minutes; in about 46 per cent of the grains and 82 per cent of the total starch in 30 minutes; and in about 57 per cent of the grains and 86 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 315.)

The hilum is distinct and a bubble is not formed there. The lamellæ are distinct at first but later are obscured. Gelatinization begins at the hilum and in the great majority of the grains progresses according to but one method. The material immediately surrounding the hilum, which probably represents the primary starch formation, is divided into three or four fragments, which are later subdivided into much smaller particles. The portion surrounding this primary starch, which probably represents a secondary starch formation, is divided by very fine striæ which are often somewhat indistinct. As the grain swells the resistant part of the secondary starch is pushed to the margin, where it forms a thick, indistinctly striated and non-lamellated band, around the inner border of which are scattered the subdivided particles of the primary starch. The marginal band grows progressively thinner and more nearly transparent, until only the thin capsule remains. The particles of the primary starch remain for a long time, but gradually grow smaller and more refractive in appearance and then disappear. In some grains the primary starch is not split apart or is split into only two pieces, which remain near one another while the secondary starch is gelatinized. Such material is very resistant and remains ungelatinized and apparently entirely unaffected after an hour's treatment by the reagent. The gelatinized grains are much swollen and have rather thin capsules. They are considerably distorted and do not retain much of the form of the untreated grain.

Comparison of the *nitric-acid* reactions between *N. abscissus* and *N. albicans* shows:

The hilum and lamellæ are as distinct as in *N. albicans,* but the lamellar structure remains visible longer. Gelatinization follows two methods instead of but one, and the majority of the grains follows closely that described for all the grains of *N. albicans,* the main difference noted being that the primary starch is always broken up into particles and the particles are much smaller, and the striæ which divide the secondary starch are much less fine and are very distinct, while the marginal band is divided into two parts—an outer granular layer and an inner spicular layer. In the second method 2 furrows or fissures extend transversely or obliquely from the hilum to the margin; the material between them and the hilum and the margin is divided first by striæ and then by irregular fissures and is gelatinized before the more resistant material at the proximal end and sides nearby, which forms a rather coarsely striated band at the proximal margin, which is slowly gelatinized. The gelatinized grains are much swollen and the capsules are as thin as in *N. albicans.* They are even more distorted and retain less resemblance to the form of the untreated grain.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 95 per cent of the entire number of grains and in more than 99 per cent of the total starch in 2 minutes, and in more than 99 per cent of the grains and total starch in 5 minutes. (Chart D 316.)

The hilum becomes distinct, attended by the formation of a bubble in a great majority of the grains. The lamellæ are usually very distinct. Gelatinization begins at the hilum and in all but very rare grains progresses according to one method. The material immediately surrounding the hilum is first divided into many large coarse granules and later subdivided into a number of

small granules which begin to gelatinize almost at once. The secondary starch becomes homogeneous-looking and very refractive, and as the primary starch and the less resistant portions of the secondary starch are gelatinized, the grain swells and the more resistant part of the secondary starch forms a refractive homogeneous-looking band at the margin, which gradually grows thinner and more nearly transparent until it is all gelatinized and only the capsule remains. The gelatinized grains are much swollen, have rather thick capsules, and are much distorted.

Comparison of the *sulphuric-acid* reactions between *N. abscissus* and *N. albicans* shows:

The hilum and lamellæ are as distinct as in *N. albicans.* Gelatinization progresses according to two methods instead of but one. The first, which is seen in a great majority of the grains, is very nearly the same as that described for all the grains of *N. albicans;* the differences are that the primary starch is usually divided into but four or five portions which gelatinize more or less independently of the secondary starch. In some grains it is not divided at all and gelatinizes as a separate part more slowly than does the secondary starch. The secondary starch is finely striated at first, but the more resistant portion forms a homogeneous-looking refractive band as in *N. albicans.* In the second method, which is not seen in *N. albicans,* 2 furrows or fissures extend transversely from either side of the hilum to the margin and the material distal to them and to the hilum is divided by concentric fissures into portions of varying size, which are gelatinized from the margin in to the hilum. The starch at the proximal end and sides nearby is pushed to the margin and then forms a homogeneous-looking, thick, refractive band which is gelatinized rather slowly, after the rest of the grain is gelatinized. The gelatinized grains are as much swollen, have as thick capsules, and are even more distorted than in *N. albicans.*

Narcissus bicolor apricot (Hybrid).

(Plate 12, fig. 72 ; Charts D 311 to D 316.)

Histologic Properties.

In *form* the grains are usually simple and isolated and there are fewer compound grains and aggregates than in either parent, and in this respect the hybrid is closer to *N. albicans.* Both compound grains and aggregates belong to the same types as were described under *N. albicans.* There are as many simple grains in which a clear distinction can be made between a primary and a secondary starch formation as in *N. abscissus.* The grains are not so often irregular in form as in *N. albicans* and much less than in *N. abscissus,* and the irregularities, if present, are due to the same causes as in *N. albicans.* The conspicuous forms are ovoid, triangular, plano-convex, and nearly round. The additional forms are irregularly quadrilateral, lenticular, and elliptical.

In form *N. bicolor apricot* shows a somewhat closer relationship to *N. albicans* than to *N. abscissus.*

The *hilum* when not fissured is not very distinct as in *N. albicans.* It is fissured as often as in *N. abscissus,* and not so deeply or so extensively as in either parent. The fissures have the following forms: (1) A single straight, longitudinal or transverse line; (2) cruciate; (3) an irregularly stellate mass of fissures. The fissures are not so varied in form as in either parent. The hilum is sometimes centric, but in the majority of the grains it is eccentric from 0.45 to 0.27, usually 0.34, of the longitudinal axis.

In the character of the hilum *N. bicolor apricot* shows a somewhat closer relationship to *N. abscissus* than to *N. albicans.* The degree of eccentricity is the same in both parents and hybrid.

The *lamellæ* are, as in *N. albicans,* not very distinct, rather fine continuous rings, with the same arrangement as in *N. albicans.* The number on the grains can not be determined.

In the character of the lamellæ *N. bicolor apricot* shows a closer relationship to *N. albicans* than to *N. abscissus.* There is, however, no marked difference in the character of the lamellæ between the two parents and the hybrid.

The grains vary in *size* from the smaller which are 4 by 4μ, to the larger which are 30 by 40μ, in length and breadth. The common sizes are 20 by 20μ, 20 by 18μ, and 18 by 22μ. In size *N. bicolor apricot* is somewhat closer to *N. albicans* than to *N. abscissus.* The three starches are, however, very close to one another in size.

Polariscopic Properties.

The *figure* as in *N. albicans* is moderately distinct and usually well defined. The lines cross at right angles or at acute angles which do not vary greatly in size. They are more often bent and bisected than in *N. albicans.* There are a very few figures which have the form of a conjugate hyperbola or of a long line bisected at both ends.

The *degree of polarization* varies from low to high (value 37), the same as in *N. albicans* and less than in *N. abscissus.* There is the same amount of variation in a given aspect of the same grain as in *N. albicans.*

With *selenite* the quadrants are, as in *N. albicans,* moderately well defined and unequal in size, but are somewhat more irregular in shape than in *N. albicans.* The colors are usually not pure, as in *N. albicans,* and there are very few grains which have a greenish tinge.

In the degree of polarization, the character of the figure, and the appearances with selenite, *N. bicolor apricot* shows a much closer relationship to *N. albicans* than to *N. abscissus.*

Iodine Reactions.

With 0.25 per cent Lugol's solution, the grains all color a moderate violet tinged with blue (value 55), the same as in *N. albicans,* and much more than in *N. abscissus.* With 0.125 per cent Lugol's solution the grains all color a light violet, the same as in *N. albicans* and more than in *N. abscissus.* After heating in water until the grains are all gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* all color a moderate to deep indigo, and the *solution* a moderate indigo, as in *N. abscissus.* If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* all color a light or a light to moderate indigo as in *N. abscissus,* the *capsules* a red or a reddish violet, and the *solution* a very deep indigo as in both parents.

Qualitatively and quantitatively the reactions with iodine of the unheated grains show a closer relationship

to *N. albicans.* After gelatinization and boiling the reactions with iodine show a closer relationship to *N. abscissus.*

ANILINE REACTIONS.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes they are light to moderately colored (value 40), the same as in *N. albicans* and more than in *N. abscissus.*

With *safranin* the grains all color very lightly at once, and in 30 minutes they are moderately colored (value 50), the same as in *N. albicans* and more than in *N. abscissus.*

In the reaction with aniline stains *N. bicolor apricot* shows a much closer relationship to *N. albicans* than to *N. abscissus.*

TEMPERATURE REACTIONS.

The temperature of gelatinization of the majority of the grains is 71° to 72.5° C., and of all is 74° to 76° C., mean 75° C.

The temperature of gelatinization of *N. bicolor apricot* is higher than in either parent and is slightly nearer that of *N. albicans,* but there is more difference between the hybrid and both parents than between the parents.

EFFECTS OF VARIOUS REAGENTS.

The reaction with *chloral hydrate* begins in 1 minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes, in about 2 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 9 per cent of the total starch in 30 minutes; in about 12 per cent of the grains and 15 per cent of the total starch in 45 minutes; and in about 18 per cent of the grains and 21 per cent of the total starch in 60 minutes. (Chart D 311.)

The hilum becomes distinct, accompanied by the formation of a bubble in a large majority of the grains, as in *N. albicans.* The lamellæ are visible and also more distinct in more grains than in *N. albicans.* The grains have become as refractive after the addition of the reagent as in *N. albicans,* but the marginal material which first shows this increased refractivity does not form so broad a band as in that starch. Gelatinization begins at discrete points on the distal margin and sides and progresses according to the two methods described under *N. albicans.* In the first, which is seen in the majority of the grains and is the same as that described for a similar number of grains of *N. albicans* and for a moderate number of the grains of *N. abscissus,* there are no differences to be noted. In the second, the main difference recorded is that the progress of gelatinization from the distal toward the proximal end is in some grains attended by a serial separation of groups of the lamellæ, as in *N. abscissus.* The gelatinized grains are somewhat more swollen, and have capsules which are not so thick as in *N. albicans,* but which are not thin as in *N. abscissus.* The grains are often more distorted than in *N. albicans.* In this reaction *N. bicolor apricot* shows qualitatively a closer relationship to *N. albicans* than to *N. abscissus.*

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 30 per cent of the total starch in 15 minutes; in about 33 per cent of the grains and 86 per cent of the total starch in 30 minutes; in about 67 per cent of the grains and 97 per cent of the total starch in 45 minutes; and in more than 99 per cent of the grains and total starch in 60 minutes. (Charts D 313 and D 314.) (See footnote, p. 516.)

The hilum and lamellæ are as distinct as in the parents. Gelatinization begins at the hilum and follows the two methods described under *N. abscissus.* In the first method, which is seen in a somewhat smaller number of grains than in *N. abscissus,* the differences noted are that the primary starch is more apt to be divided into but three or four portions, which remain clumped together in the center of the grain and are the last part of the grain to be dissolved, and the striæ which divide the secondary starch are coarser than in *N. abscissus.* The greater number of the grains follow the second method which is the same as in *N. abscissus,* but in some it is exactly as in *N. albicans.* The grains are all dissolved before they are completely gelatinized. In this reaction *N. bicolor apricot* shows, qualitatively, a closer relationship to *N. abscissus* than to *N. albicans.*

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 39 per cent of the total starch in 15 minutes; in about 27 per cent of the grains and 73 per cent of the total starch in 30 minutes; in about 50 per cent of the grains and 85 per cent of the total starch in 45 minutes; and in about 63 per cent of the grains and 90 per cent of the total starch in 60 minutes. (Chart D 313.)

The hilum and lamellæ are as distinct as in the parents. Gelatinization begins at the hilum and follows the two methods described under *N. abscissus,* though fewer grains follow the second method than in *N. abscissus.* The main difference noted is that the starch immediately surrounding the hilum is more apt to remain clumped together in the center of the grain, as in a few grains of *N. albicans.* The striæ also are not so fine as in *N. abscissus.* The gelatinized grains are more swollen, have thinner capsules, and are more distorted than in either parent, showing, however, a closer resemblance to *N. abscissus* than to *N. albicans.* In this reaction *N. bicolor apricot* shows qualitatively a closer relationship to *N. abscissus* than to *N. albicans.*

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 4 per cent of the grains and 16 per cent of the total starch in 5 minutes; in about 28 per cent of the grains and 56 per cent of the total starch in 15 minutes; in about 44 per cent of the grains and 68 per cent of the total starch in 30 minutes; in about 52 per cent of the grains and 76 per cent of the total starch in 45 minutes, and in about the same percentage of the grains and 80 per cent of the total starch in 60 minutes. (Chart D 315.)

The hilum and lamellæ are as distinct as in the parents. Gelatinization begins at the hilum and follows the two methods described under *N. abscissus,* though fewer grains follow the second type than in *N. abscissus.* The main differences noted in the process are that the primary starch is more apt to remain clumped together in the center of the grain, as described for some grains

of both *N. albicans* and *N. abscissus*, although in many grains it is scattered widely as in both parents, and the particles of the primary starch are larger, while the striæ are even less fine than in *N. abscissus*. The gelatinized grains are much swollen and have thinner capsules and are more distorted than in either parent, which are accentuations of characteristics of *N. abscissus*. In this reaction *N. bicolor apricot* shows qualitatively a closer relationship to *N. abscissus* than to *N. albicans*.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 93 per cent of the entire number of grains and 98 per cent of the total starch in 2 minutes, and in about 99 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 316.)

The hilum and lamellæ are as distinct as in both parents. Gelatinization begins at the hilum and progresses according to the two methods described in *N. abscissus*. In the first method, which is seen in a larger majority of the grains than in *N. abscissus*, the differences noted are that the primary starch is more apt to be divided into but two or three pieces, which remain clumped together in the center of the grain or is not divided at all, but remains as a simple grain which is gelatinized independently and after the secondary starch. In the second method the only difference noted was that the distal material usually becomes more refractive and then a finely granular mass which is gelatinized at the hilum first, then outward toward the margin, instead of being divided by concentric fissures into portions of varying size which are gelatinized at the margin first, then inward toward the hilum. The gelatinized grains are as much swollen and more distorted than in either parent, and have capsules which are not so thick as in either parent. In this reaction *N. bicolor apricot* shows qualitatively a closer relationship to *N. abscissus* than to *N. albicans*.

20. Starches of Narcissus empress, N. albicans, and N. madame de graaff.

Starch of *Narcissus albicans* is described on pages 560 to 564.

Narcissus empress (Seed Parent).

(Plate 13, fig. 73; Charts D 317 to D 322.)

Histologic Properties.

In *form* the grains are usually simple and isolated, with the exception of a moderate number which occur in small aggregates of 2, 3, or 4 grains linearly or pyramidally arranged. A moderate number of compound grains have from 2 to 6 or 7 components, and there are a few grains which are combinations of compounds and aggregates. The compound grains belong to two types: In the first there are 2, 3, or 4 small or moderate-sized grains, each with a hilum and 3 or 4 lamellæ, and all are surrounded by 3 or 4 common lamellæ. In the second there are 6 or 7 hila, each hilum with 1 lamella surrounding it, all in turn inclosed by 4 or 5 secondary lamellæ. There are a great number of grains which show a rather small primary grain, around which are a number of secondary lamellæ, somewhat or entirely changing the original form of the grain. The starches of the two deposits are differentiated from one another very plainly by a distinct, rather deep furrow, and by differences in their degrees of refractivity. The grains are usually irregular in form and the irregularities are due to the following causes: (1) Small or large rounded protuberances from the proximal end and the sides, or, rarely, from the distal end; (2) depressions and elevations in the margin and surface of the grain, giving it a wavy or undulating outline; (3) the greater development of one part of the distal end; (4) secondary deposits of starch in various places which change the original form of the grain; (5) irregularly placed and varying-sized pressure facets; (6) deviation of the longitudinal axis usually at the middle or distal end, with a consequent bending of the grain; (7) two indentations, one on either side of and just below the apex of the proximal end. The conspicuous forms are ovoid, which may be broad or narrow and which may have either a pointed or a blunt end, lenticular, nearly round, and dome-shaped. There are also pyriform, triangular with rounded base and angles, plano-convex, clam-shell, and irregularly quadrilateral grains.

The *hilum*, when not fissured, is a moderately distinct, small, round, or, rarely, lenticular-shaped spot, but it is usually fissured, and the fissures are deep and extensive and take the following forms: (1) A single, short, straight line, placed transversely, obliquely, or, rarely, longitudinally; (2) T- and Y-shaped; (3) cruciate, irregularly X-shaped, and V-shaped; (4) a flying-bird figure. The hilum is sometimes centric, but in the majority of the grains is eccentric from 0.42 to 0.31, usually 0.35, of the longitudinal axis.

The *lamellæ* are usually not distinct, but in some grains they are moderately distinct, and appear as rather coarse continuous rings which have in general the form of the outline of the grain. In the grains which have a secondary deposit of starch, lamellæ are rarely visible in the primary but are very distinct in the secondary deposit. The number counted on some of the larger grains varies from 4 to 12, usually 6.

In *size* the grains vary from the smaller which are 4 by 4μ, to the larger forms which are 30 by 40μ, and the larger elongated forms which are 34 by 32μ, in length and breadth. The common sizes are 24 by 30μ and 28 by 14μ.

Comparison of the *histologic characteristics* between *N. albicans* and *N. empress* shows:

The grains of *N. albicans* occur more frequently in aggregates, and there are more compound grains of the same type than were found in *N. empress*. The grains are rather less irregular than in *N. empress*, but the irregularities are due to the same causes. The conspicuous forms are ovoid, which are usually broader and more rounded than in *N. empress*: and nearly round and short elliptical, neither of which is noted in *N. empress*. There are the same additional forms, but all are more rounded than those of *N. empress*.

The *hilum* when not fissured is not so distinct as in *N. empress*, and is fissured as often but not so extensively. The fissures have the same forms as in *N. empress*, except that a long, irregularly branching line is also sometimes seen. The hilum is not so eccentric as in *N. empress*, the average eccentricity being 0.38 of the longitudinal axis.

The *lamellæ* are not so distinct and are finer than in *N. empress*, but do not show any other noteworthy differences.

In *size* the grains are somewhat smaller, the common sizes being 22 by 26μ, 22 by 22μ, and 22 by 18μ.

Polariscopic Properties.

The *figure* is often not very distinct and is rarely well defined. The lines are broad and often bent and bisected, and they cross at acute angles of widely varying size. There are sometimes 5 or 6 lines instead of 4, and occasionally the figure is a conjugate hyperbola, or a long line bisected at both ends instead of a cross.

The *degree of polarization* varies from low to high (value 42). In most of the grains it is moderate or low to moderate. There is considerable variation in a given aspect of an individual grain.

With *selenite* the quadrants are not well defined, are unequal in size and often irregular in shape. The colors are usually not pure and there are a few grains which have a greenish tinge.

Comparison of the *polariscopic properties* between *N. albicans* and *N. empress* shows:

The *figure* is usually more distinct and less poorly defined. The lines are less often bent or bisected, and they cross at acute angles which do not vary greatly in size. There are fewer figures in the form of a conjugate hyperbola, or of a long line with bisected ends.

The *degree of polarization* varies from low to high (value 37), less than *N. empress*. There are more grains with a low or a low to moderate degree of polarization than in *N. empress*, and there is less variation in a given aspect of an individual grain.

With *selenite* the quadrants are more often well defined and are less irregular in shape. The colors are more often not pure and there are fewer grains which have a greenish tinge.

Iodine Reactions.

With 0.25 per cent Lugol's solution, the grains all color a moderate violet tinged with blue (value 50), and the color deepens with moderate rapidity until the grains are all colored very deeply and with more of a bluish tint. With 0.125 per cent Lugol's solution the grains all color a light violet, and the color deepens with moderate rapidity until all the grains are deeply colored and have a somewhat bluish tint. After heating in water until the grains are all gelatinized and then treating with a 2 per cent Lugol's solution, the *grains* all color a moderate indigo, and the *solution* a deep indigo. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the *grain-residues* all color a light indigo, the *capsules* a red or reddish violet, and the *solution* a deep indigo-blue.

Comparison of the *iodine reactions* between *N. albicans* and *N. empress* shows:

With 0.25 per cent Lugol's solution the grains color somewhat more (value 55), and so also with 0.125 per cent Lugol's solution. After heating in water until the grains are gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized grains and the solution react as in *N. empress*. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the grain-residues, the capsules, and the solution react as in *N. empress*.

Aniline Reactions.

With *gentian violet* the grains all color, very lightly, at once, and in 30 minutes they are all light to moderately colored (value 43). The grains are all equally deeply colored and there is no difference in the depth of color in different parts of individual grains.

With *safranin* the grains all color very lightly at once, and in 30 minutes they are all moderately colored (value 53), more than with gentian violet. The grains are all equally deeply colored and there is no difference in the depth of color in different parts of individual grains.

Comparison of the *aniline reactions* between *N. albicans* and *N. empress* shows:

With *gentian violet* the grains color light to moderately (value 40), somewhat less than in *N. empress*.

With *safranin* they color moderately (value 50), somewhat less than in *N. empress*.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 70° to 71° C., and of all is 73° to 74° C., mean 73.5° C.

Comparison of the *temperature reactions* between *N. albicans* and *N. empress* shows:

The temperature of gelatinization is the same—73° to 75° C., mean 74° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 14 per cent of the grains and 16 per cent of the total starch in 30 minutes; in about 19 per cent of the grains and 23 per cent of the total starch in 45 minutes; and in about 21 per cent of the grains and 26 per cent of the total starch in 60 minutes. (Chart D 317.)

The hilum becomes distinct, accompanied by the formation of a bubble in a moderate number of grains. The lamellæ are at first not visible, but later become moderately distinct in all the grains. The grains become more refractive, the first part to show this is a rather narrow portion at the margin, which becomes moderately refractive soon after the reagent is added. Gelatinization begins at various points on the distal margin, except in the lenticular, the elongated ovoid, and the elliptical grains in which it begins at either end and progresses according to two methods. In the first method, which is seen in a majority of the grains, gelatinization spreads around the margin until the whole distal end is involved and then moves toward the proximal end. Its advance is accompanied by the serial separation and gelatinization of groups of lamellæ until only a small portion immediately surrounding the hilum remains, and this gelatinizes rather rapidly and in all parts at once as the hilum enlarges. In the lenticular, elongated ovoid, and elliptical grains gelatinization advances from either end toward the center and is accompanied by fissuring and some granulation of the grain. In a few grains in which gelatinization begins at the distal margin, serial separation of the lamellæ does not occur, and instead gelatinization progresses from the points at which it begins towards the distal end, by means of deep cracks and

depressions in the grain, which become gradually wider and deeper until they coalesce. The hilum is reached by this time, it swells moderately rapidly, and the material immediately surrounding it is rapidly gelatinized. The gelatinized grains are not greatly swollen, and have rather thick capsules. They are much distorted, but retain some resemblance to the form of the untreated grain.

Comparison of the *chloral-hydrate* reactions between *N. albicans* and *N. empress* shows:

A bubble is much more frequently found at the hilum and is smaller than that formed in the grains of *N. empress.* The lamellæ, which are not distinct at first, later become more distinct than in *N. empress,* and the grains grow somewhat more refractive after the reagent is added. Gelatinization as in *N. empress* begins in the majority of the grains at various points on the margin, and progresses according to the two methods described in that starch. The progress of gelatinization is smoother, and serial separation of the lamellæ and cracking and fissuring of the ungelatinized material does not occur. The gelatinized grains are somewhat swollen and have thinner capsules and are somewhat more distorted than in *N. empress.*

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 45 per cent of the total starch in 15 minutes; in about 20 per cent of the grains and 92 per cent of the total starch in 30 minutes; in about 65 per cent of the grains and 98 per cent of the total starch in 45 minutes; and in about 90 per cent of the grains and in more than 99 per cent of the total starch in 60 minutes. (Chart D 318.) (See footnote, page 516.)

The hilum becomes distinct, unattended by the formation of a bubble. The lamellæ also become distinct, but usually are obscured during the reaction. Gelatinization begins at the hilum and progresses according to three methods. In the first method, which is seen in a small majority of the grains, the primary starch immediately around the hilum is divided by fissures into two to four portions, which are again divided into many fine granules by irregular fissuring. The secondary starch is divided by fine striæ and loses its lamellated appearance. The granular primary starch begins to gelatinize and the grains to swell. The less resistant portion of the secondary starch is also gelatinized and the more resistant part forms a finely striated band at the margin, which has a spicular inner border. The interior of the grain is granular first and then becomes clear and the marginal band gradually becomes thinner and more nearly transparent, until it also is gelatinized and only the capsule is left. In the second method, which is seen in a moderate number of grains, a sheaf of irregular fissures extends from the hilum to the distal margin, dividing the starch in their path into rather coarse, irregular granules which begin to gelatinize. The rest of the grain is finely striated, and as the granular material is gelatinized and the grain swells, this striated portion is pushed to the margin, where it forms a striated marginal band which does not extend completely around the margin. At the point where it is not complete the capsule is dissolved and the contents of the grain flow out and are dissolved. In the third method, which is also seen in a moderate number of grains, 2 furrows or actual fissures extend horizontally or obliquely from the hilum to the margin and the material just distal to the hilum is divided by fissures into coarse granules and the rest of the starch distal to the hilum and the furrows loses its lamellar structure and becomes a finely granular mass which is afterwards divided by irregular longitudinal fissures radiating from the hilum. The proximal material is finely striated and is very resistant. The grain swells slowly and in most of the grains the granular distal portion is gelatinized and the capsules dissolved before the proximal starch shows any sign of change; in others it becomes more refractive in appearance and somewhat thinner, but is never completely gelatinized before solution occurs. The gelatinized grains are much swollen, have rather thin capsules, and are considerably distorted.

Comparison on the *chromic-acid* reactions between *N. albicans* and *N. empress* shows:

The hilum and lamellæ are as distinct as in *N. empress.* Gelatinization progresses according to two instead of three methods. The first method, which is seen in a small majority of the grains, resembles closely the second method described for a moderate number of grains of *N. empress,* the only difference noted being that 2 sheaves of fissures sometimes extend from the hilum to the margin, one to the distal and one to the proximal end, and the capsule is dissolved at these two points instead of at but one. The second method, which is seen in a large minority of the grains, is nearly the same as the third method, which is seen in a moderate number of grains of *N. empress:* the difference noted is that the material distal to the hilum and the horizontal furrows from the hilum is divided by coarse striæ into rows of granules arranged according to the rows of lamellæ, instead of losing its structural appearance and becoming a finely granular mass. The grains are always dissolved before they are completely gelatinized.

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 13 per cent of the total starch in 15 minutes; in about 27 per cent of the grains and 50 per cent of the total starch in 30 minutes; in about 39 per cent of the grains and 61 per cent of the total starch in 45 minutes; and in about 44 per cent of the grains and 78 per cent of the total starch in 60 minutes. (Charts D 319 and D 320.)

The hilum is distinct and a bubble is never formed there. The lamellæ are distinct, and often some traces of a lamellar structure remain at the margin after the rest of the grain is completely gelatinized. Gelatinization begins at the hilum and follows two methods of procedure. In the first, which is seen in a majority of the grains, the portion immediately surrounding the hilum is split into many fine particles or granules, which, as the grain swells, are widely scattered. The rest of the grain is divided by fine striæ and 2 refractive fissures that extend obliquely from some point near the hilum to the margin; the portion of the grain included between these 2 fissures becomes more refractive and homogeneous-looking, and gelatinizes before the rest of the grain. The rest of the starch is divided into rows of fine granules which are arranged in rows corresponding to the

rows of lamellæ. As the grain swells with the gelatinization of the less resistant parts of the grain, the more resistant part is pushed to the margin, where it forms a granular band, except at that part of the margin at which the material has been gelatinized. This band shows two or three lamellar markings. It grows progressively thinner and more nearly transparent and loses its lamellated appearance and is finally completely gelatinized. The granules formed from the starch around the hilum remain for some time after the rest of the grain is gelatinized, but are finally also gelatinized. In the second method 2 furrows extend transversely or rarely obliquely from either side of the hilum to the margin, and the starch included between them and the hilum and the margin becomes finely granular and is then slowly gelatinized without much swelling of the grain. The portion at the proximal end and sides nearby is striated and gradually grows thinner and more nearly transparent. These grains are practically never completely gelatinized. The gelatinized grains are not much swollen, have thick capsules, and are not much distorted.

Comparison of the *pyrogallic-acid* reactions between *N. albicans* and *N. empress* shows:

The hilum is more distinct and the lamellæ are not so distorted and do not remain distinct so long as in *N. empress.* Gelatinization follows but one method instead of two as in *N. empress.* It is essentially the same as that described for the majority of the grains of *N. empress.* The differences noted are that the granules formed from the starch immediately surrounding the hilum are not so numerous nor so small as in *N. empress,* and there are no fissures which extend to the margin and inclose a less resistant part of the grain. The striæ which divide the rest of the grain are much finer and are not distinct in all the grains, and the marginal band has a homogeneous instead of a striated appearance. The gelatinized grains are more swollen, have thinner capsules, and are more distorted than those of *N. empress.*

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 12 per cent of the total starch in 5 minutes; in about 15 per cent of the grains and 52 per cent of the total starch in 15 minutes; in about 22 per cent of the grains and 58 per cent of the total starch in 30 minutes; in about 35 per cent of the grains and 65 per cent of the total starch in 45 minutes; and in about 40 per cent of the grains and 70 per cent of the total starch in 60 minutes. (Chart D 321.)

The hilum is distinct and no bubbles are formed there, and if fissures are present in the untreated grain they become wider and more extensive after the reagent is added. The lamellæ are distinct and some traces of a lamellar structure remain at the margin after the rest of the grain is completely gelatinized. Gelatinization begins at the hilum and follows two methods of procedure. In the first, which occurs in a majority of the grains, the portion immediately about the hilum, which probably represents a primary formation of starch, is split into many fine particles which, as the grain swells, are widely scattered. The portion of the grain surrounding this primary starch, which probably represents a secondary formation, is divided by fine striæ, and 2 refractive fissures or furrows extend obliquely from adjacent points of the depression, which separates the primary from the secondary starch, to or nearly to the margin. The portion of the grain included between these 2 furrows becomes more refractive in appearance and is considerably fissured in a longitudinal direction. It is the least resistant part of the grain and is soon gelatinized. The rest of the secondary deposit is striated and then divided into rows of fine granules distributed according to the arrangement of the lamellæ. As the grain swells with the gelatinization of the less resistant parts, the more resistant part is pushed to the margin, where it forms around the whole margin (except at the distal end, where all or nearly all the material is gelatinized) a granular and lamellated band, around the inner border of which the small particles of the primary starch are arranged in clumps. The marginal band grows progressively thinner and more nearly transparent and loses its lamellated appearance, but retains that of a single row of granules which is divided in many places by small cracks in the margin. The primary starch granules persist for a long time, but are finally gelatinized. In the second method of gelatinization 2 furrows extend transversely, rarely obliquely, from either side of the hilum to the margin, and the material included between them and the hilum and the margin becomes finely granular and irregularly fissured. It gelatinizes without much swelling or pushing to the margin of the resistant portion, the granules from the hilum outward merely becoming smaller and more refractive and finally disappearing. The starch at the proximal end and sides nearby is striated, and as the most resistant part of the grain very gradually grows more refractive and smaller in amount, such grains rarely are completely gelatinized.

The gelatinized grains are not much swollen and have thick capsules. They are not much distorted and retain some resemblance to the form of the untreated grain. The capsules of a few grains are dissolved at several points and the grains are slit at these points nearly to a common center.

Comparison of the *nitric-acid* reactions between *N. albicans* and *N. empress* shows:

The hilum is more distinct than in *N. empress,* and the lamellæ are not so distinct nor so persistent as in that species. Gelatinization, with the exception of very rare grains, follows but one method, which is essentially the same as the first method described under *N. empress.* The differences noted are that the particles of the primary starch are not so numerous nor so small as in *N. empress,* there are no fissures extending to the hilum which incloses a less resistant portion of the grain, and the striæ which appear radiating throughout the secondary starch are very much finer and not so distinct, while the marginal band which is formed about the entire margin is only faintly striated and soon assumes a homogeneous appearance. The gelatinized grains are more swollen, have rather thin capsules, and are much more distorted than those of *N. empress.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 84 per cent of the entire number of grains and 95 per cent of the total starch in 2 minutes, and in about 97 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 322.)

The hilum becomes distinct, attended by the formation of a bubble, in a majority of the grains. The lamellæ are distinct at first, but later are somewhat obscured. Gelatinization begins at the hilum and progresses according to two methods. In the first, which is seen in a majority of the grains, the portion of the grain immediately surrounding the hilum, which probably represents a primary starch formation, is partially separated from the secondary starch by a refractive fissure, and both the primary and the secondary portions of the grain are divided by refractive fissures into concentric portions of varying size; they gelatinize and swell at the same time; the primary grain following closely the enlargement of the secondary starch, the material becomes at first more, then less refractive, and loses its dense appearance, and finally the line of demarcation between primary and secondary starch also disappears. In a few grains the primary starch is divided by coarse striæ into a number of coarse, cylindrical granules, which, as the secondary starch swells, likewise swell and line its inner border until nearly the end of the reaction, when they disappear as the rest of the grain loses its structural appearance. In the second method, which is seen in a moderate number of grains, 2 furrows extend transversely or obliquely from the hilum on either side to the margin and the starch distal to these and the hilum is divided by irregular concentric refractive fissures into portions of unequal size. This is gelatinized rapidly with much swelling and distortion of the capsule, and the proximal starch, which forms a very finely striated band at the proximal margin, becomes thinner and more refractive and more nearly transparent, until all the material is gelatinized and only the capsule remains. The gelatinized grains are much swollen, have rather thin capsules, and are very much distorted.

Comparison of the *sulphuric-acid* reactions between *N. albicans* and *N. empress* shows:

The hilum and lamellæ are as distinct as in *N. empress.* Gelatinization progresses according to but one method, which is very much like that described for the majority of the grains of *N. empress.* The points of difference are that the primary starch is divided into granules which are gelatinized somewhat previous to the gelatinization of the secondary starch. The secondary starch is not divided by refractive fissures, but becomes homogeneous-looking and more refractive. The more resistant part of this secondary starch forms a refractive marginal band as the less resistant portion and the primary starch are gelatinized. The marginal band is later gelatinized. The gelatinized grains are as much swollen, do not have thin capsules, and are not so much distorted as in *N. empress.*

Narcissus madame de graaff (Hybrid).

(Plates 13 and 14, figs. 75, 77, and 80; Charts D 317 to D 322.)

Histologic Properties.

In *form* the grains are much more often simple and isolated than in either parent, in which characteristics it is closer to *N. empress* and far removed from *N. albicans*, and the aggregates and compound grains seen are of the same types as those of *N. empress.* There are also a number of grains with well-defined pressure facets on either side of the distal end, indicating that they have existed in aggregates. There are also the same number of simple grains in which a primary and a secondary starch formation can be seen. The grains are more irregular in form than in *N. albicans* and somewhat more irregular than in *N. empress,* and the irregularities are due to the same causes as described under *N. empress.* The conspicuous forms more closely resemble those of *N. empress* and are ovoid, nearly round, broad elliptical, and triangular with rounded angles and base. The additional forms are lenticular, plano-convex, irregularly quadrilateral, clam-shell-shaped, and pyriform.

In form the grains somewhat more closely resemble *N. empress* than *N. albicans,* and some characteristics of *N. empress* are further accentuated in the hybrid.

The *hilum* is not so frequently nor so extensively fissured as in *N. empress,* nor even as in *N. albicans,* and the fissures have the following forms: (1) A short, straight or curved line placed horizontally or obliquely; (2) an irregular Y-shaped figure placed in the transverse axis or obliquely; (3) an X, T, or cruciform figure placed in the transverse and longitudinal axes of the grain; (4) a flying-bird-like figure. The hilum is sometimes centric, but in the majority of the grains is eccentric from 0.45 to 0.29, usually 0.37, of the longitudinal axis.

In the character and eccentricity of the hilum *N. madame de graaff* shows a closer relationship to *N. albicans* than to *N. empress.*

The *lamellæ* are usually not distinct, and when they can be seen they are as fine as those of *N. albicans* and have the same arrangement and characteristics as noted in both parents. The number counted on some of the larger grains varies from 8 to 16, usually 10.

In the characteristics and number of the lamellæ *N. madame de graaff* is closer to *N. albicans* than to *N. empress.*

The grains vary in *size* from the smaller which are 3 by 3μ, to the larger which are 36 by 42μ, rarely, 44 by 50μ, in length and breadth. The common sizes are 20 by 24μ, 24 by 24μ, and 30 by 24μ. In size *N. madame de graaff* shows a somewhat closer relationship to *N. empress.* The parents and the hybrid do not vary much in size.

Polariscopic Properties.

The *figure* as in *N. empress* is often not distinct, and is, rarely, well defined. The lines cross at acute angles, which vary widely in size, and they are often bent and bisected, not so frequently as in *N. empress,* more frequently, however, than in *N. albicans.* There are as few figures in the form of a conjugate hyperbola, or a long line with bisected ends, as in *N. albicans.*

The *degree of polarization* varies from low to high (value 37), the same as in *N. albicans,* and there is the same amount of variation in a given aspect of an individual grain.

With *selenite* the quadrants as in *N. empress* are rarely well defined and are unequal in size, but not so often irregular in shape. The colors are not pure and there are few grains which show a greenish tinge.

In the degree of polarization, the character of the figure, and the appearance with selenite *N. madame de graaff* shows a closer relationship to *N. empress* than to *N. albicans.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains are all colored a moderate violet tinged with blue (value 50),

the same as in *N. empress*, and the color deepens with moderate rapidity until the grains are very deeply colored, and have assumed more of a bluish tint. With 0.125 per cent Lugol's solution, the grains all color a light violet, the same as in *N. empress*, and they deepen with moderate rapidity until they are deeply colored. After heating in water until the grains are all gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* all color a moderate indigo and the *solution* a deep indigo, as in both parents. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the *grain-residues* color a light indigo; the *capsules* a red or reddish violet, and the *solution* a very deep indigo-blue.

Qualitatively and quantitatively the iodine reactions of the ungelatinized grains show a closer relationship to *N. empress* than to *N. albicans*. The iodine reactions of the grains after they have been gelatinized and boiled are the same in both parents and hybrid.

Aniline Reactions.

With *gentian violet* the grains all color very lightly, at once, and in 30 minutes they are light to moderately colored (value 43), the same as in *N. empress* and somewhat more than in *N. albicans*.

With *safranin* the grains all color, very lightly, at once, and in 30 minutes they are moderately colored (value 53), the same as in *N. empress* and somewhat less than in *N. albicans*.

In the reaction with aniline stains *N. madame de graaff* shows a somewhat closer relationship to *N. empress* than to *N. albicans*.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 70° to 72° C., and of all is 73.5° to 75° C., mean 74.25° C. The temperature of gelatinization of *N. madame de graaff* is the same as both parents.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in a few grains in 30 seconds. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 17 per cent of the grains and 20 per cent of the total starch in 15 minutes; in about 28 per cent of the grains and 35 per cent of the total starch in 30 minutes; in about 40 per cent of the grains and 43 per cent of the total starch in 45 minutes; and in about 44 per cent of the grains and 48 per cent of the total starch in 60 minutes. (Chart D 310.)

The hilum becomes distinct, accompanied by the formation of a small bubble less frequently than in either parent. The lamellæ are at first not distinct but later become as distinct as in *N. empress*. The grains become as refractive as in *N. empress* after the addition of the reagent. Gelatinization begins at various discrete points on the distal margin in the majority of the grains, and in the lenticular, elongated ovoid, and elliptical grains at either end. The progress of gelatinization is very close to that described under *N. empress*, except that it is smoother and is accompanied by less cracking and hollowing out of the ungelatinized material. The gelatinized grains are somewhat swollen, have as thick capsules, and are as much distorted as in *N. empress*. In this reaction *N. madame de graaff* shows qualitatively a somewhat closer relationship to *N. empress* than to *N. albicans*.

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 33 per cent of the total starch in 15 minutes; in about 14 per cent of the grains and 77 per cent of the total starch in 30 minutes; in 33 per cent of the grains and 91 per cent of the total starch in 45 minutes; and in about 72 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 318.) (See footnote, page 516.)

The hilum and lamellæ are as distinct as in both parents. Gelatinization begins at the hilum and progresses according to two of the methods noted under *N. empress*, only one of which resembles one noted under *N. albicans*. The first, which is observed in a great majority of the grains and is nearly the same as that seen in a small majority of the grains of *N. empress*, is not noted at all in the grains of *N. albicans*. The differences found are that the primary starch forms coarse, more distinct, and more refractive granules, and the secondary starch is divided by more distinct and not such fine striæ. In the second method, which is seen in a moderate number of the grains of *N. empress* and a large minority of the grains of *N. albicans*, the resemblance is closer to *N. empress* than to *N. albicans*, the only difference between the hybrid and *N. empress* being that the material distal to the hilum and the 2 transverse furrows which extend from it is more apt to be fissured by irregular longitudinal fissures from the hilum.

A smaller number of grains than in *N. empress* are completely gelatinized before they are dissolved. The gelatinized grains are as swollen, have as thin capsules, and are as distorted as in *N. empress*.

In this reaction *N. madame de graaff* shows qualitatively a closer relationship to *N. empress* than to *N. albicans*.

The reaction with *pyrogallic acid* begins in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 32 per cent of the total starch in 15 minutes; in about 24 per cent of the grains and 56 per cent of the total starch in 30 minutes; in about 36 per cent of the grains and 68 per cent of the total starch in 45 minutes; and in about 50 per cent of the grains and 79 per cent of the total starch in 60 minutes. (Charts D 319 and D 320.)

The hilum and lamellæ are as distinct as in *N. albicans*. Gelatinization begins at the hilum as in the parents and proceeds according to two methods noted under *N. empress*. The great majority of the grains follows closely the method described for a similar number of grains of *N. empress* and in general for practically all the grains of *N. albicans*. The differences found are the same as those noted under *N. albicans*, and the method followed shows a close relationship to that starch. A very small number are gelatinized according to the second method described under *N. empress*, but more swelling occurs and gelatinization is completed in some of the grains. The gelatinized grains are as much swollen and distorted as in *N. albicans*, but have as thick cap-

sules as in *N. empress.* In this reaction *N. madame de graaff* shows qualitatively a closer relationship to *N. albicans* than to *N. empress.*

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 29 per cent of the total starch in 15 minutes; in about 12 per cent of the grains and 49 per cent of the total starch in 30 minutes; in about 29 per cent of the grains and 58 per cent of the total starch in 45 minutes; and in about 32 per cent of the grains and 65 per cent of the total starch in 60 minutes. (Chart D 321.)

The hilum and lamellæ are as distinct as in *N. albicans.* Gelatinization begins at the hilum, as in the parents, and proceeds according to the two methods noted under *N. empress.* The great majority of the grains follow closely the first type as described under *N. empress,* except that 2 fissures do not so frequently extend from the line dividing the primary from the secondary starch, and the primary material is not divided into such fine particles. A small number are gelatinized according to the second method described, but more swelling occurs and less distinct granulation. The gelatinized grains are usually as swollen and have as thick capsules as in *N. empress,* but some are as in *N. albicans.*

In this reaction *N. madame de graaff* shows qualitatively a closer relationship to *N. empress* than to *N. albicans.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 86 per cent of the entire number of grains and 98 per cent of the total starch in 2 minutes; and in about 97 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 322.)

The hilum becomes distinct, attended by the formation of a small bubble in a smaller number of grains than in either parent. The lamellæ are as distinct as in both parents. Gelatinization begins at the hilum and progresses according to the two methods described in *N. empress.* The first method, which is seen in a great majority of the grains, is the same as that described for a majority of the grains of *N. empress,* and resembles that described for all the grains of *N. albicans.* In the second type, which is seen in a rather small minority of the grains, the differences noted are that the concentric fissures that divide the portion distal to the hilum are regular and follow the lines of the lamellæ, and the material at the proximal end is distinctly striated and the striæ remain distinct for some time during the gelatinization of the grain. In this reaction *N. madame de graaff* shows qualitatively a closer relationship to *N. empress* than to *N. albicans.*

21. Starches of Narcissus weardale perfection, N. madame de graaff, and N. pyramus.

Starch of *N. madame de graaff* (pollen parent) is described on pages 570 to 572.

Narcissus weardale perfection (Seed Parent).

(Plate 13, fig. 76; Charts D 323 to D 328.)

In *form* the grains are usually simple and isolated, but there is a moderate number of both compound grains and aggregates. The compound grains belong to two types, of which the first, which consists of 2 moderate-sized grains adherent and surrounded by 1 or 2 common secondary lamellæ, is much more often seen than the second, which consists of a number of hila in an amorphous-appearing mass of starch that is surrounded by 1 or 2 secondary lamellæ. The aggregates are always doublets of small or common-sized grains. A small majority of the simple grains shows clearly a primary grain which has been inclosed by 4 or 5 secondary lamellæ. The grains are usually regular, but sometimes irregular, and any irregularities which occur are due to the following causes: (1) Small, irregular elevations and depressions in the surfaces and margins of the grains; (2) 1 or 2 small rounded or large rounded or pointed protuberances from either end or side; (3) a greater development of one part of the distal end or of one side. The conspicuous forms are ovoid, plano-convex, triangular with rounded angles, and nearly round. The additional forms are elliptical, irregularly quadrilateral, and rarely pyriform. The broader forms are somewhat flattened, the others are not.

The *hilum,* when not fissured, is a small round or, rarely, lenticular spot which is not very distinct. It is fissured in the great majority of the grains and the fissures have the following forms: (1) A straight, transverse, or, rarely, oblique or longitudinal, line; (2) V-shaped; (3) T-, -Y, or cruciate-shaped; (4) a flying-bird form. The hilum is sometimes centric, but in the majority of the grains it is eccentric from 0.45 to 0.29, usually 0.35, of the longitudinal axis.

The *lamellæ* in most of the grains are not very distinct, and in a moderate number are not visible in every part of the grain. They are usually more distinct near the hilum than near the margin. They are rather coarse continuous rings which have in general the form of the outline of the grain, but which follow it closely only near the margin. The number counted on some of the larger grains varies from 8 to 12, usually 10.

In *size* the grains vary from the smaller which are 3 by 3μ, to the larger which are 30 by 40μ and 40 by 36μ, in length and breadth. The common sizes are 18 by 20μ, 22 by 22μ, and 24 by 20μ.

Comparison of the *histologic properties* between *N. madame de graaff* and *N. weardale perfection* shows:

There are fewer compound grains and aggregates. The compound grains belong to the two types described under *N. weardale perfection,* but in the first type, which is the one most commonly seen, there may be 3, 4, or 5 components instead of but 2. There is a rather larger majority of the grains in which both a primary and a secondary formation of starch can be seen. The grains are rather more irregular in form and the irregularities are due to: (1) Elevations and depressions in the margin and top surface; (2) pressure facets at the distal end and sides; (3) protuberances from either end or sides. The grains are somewhat more varied in form.

The *hilum* is not so often fissured and the fissures are not so deep nor so extensive, but have the same forms. It is somewhat less eccentric, the usual degree of eccentricity being 0.37 of the longitudinal axis.

The *lamellæ* are somewhat less distinct and are not so coarse.

In *size* the grains are, on the whole, larger than in *N. weardale perfection*, the common sizes are 20 by 32μ, 24 by 24μ, and 30 by 24μ in length and breadth.

POLARISCOPIC PROPERTIES.

The *figure* is usually distinct and well defined. The lines cross at an acute angle which does not vary greatly in size and are only rarely not bent nor bisected. There are but few figures in the form of an hyperbola or of a long line bisected at both ends.

The *degree of polarization* varies from low to high (value 37). There are very few grains in which it is high and many in which it is low or moderate. There is considerable variation in a given aspect of an individual grain.

With *selenite* the quadrants are usually clean-cut, unequal in size, but regular in shape. The colors in the great majority of the grains are not pure, and there are very few which show a greenish tinge.

Comparison of the *polariscopic properties* between *N. madame de graaff* and *N. weardale perfection* shows:

The *figure* is not so distinct nor so well defined. The lines cross at angles which vary greatly in size and are often bent and bisected. There are very few grains as in *N. weardale perfection* in which the figure has the form of a conjugate hyperbola, or of a long line bisected at both ends.

The *degree of polarization* is low to high (value 37), and there are more grains in which it is moderate and fewer in which it is low. There is somewhat less variation in a given aspect of the same grain.

With *selenite* the quadrants are less clean-cut and more often irregular in shape. The colors are somewhat more pure, and there are more which have a greenish tinge.

IODINE REACTIONS.

With 0.25 per cent Lugol's solution the grains all color a moderate violet tinged with blue (value 55), and the color deepens with moderate rapidity until the grains are all colored very deeply and have assumed much more of a bluish tint. With 0.125 per cent Lugol's solution, the grains all color a light violet, and the color deepens with moderate rapidity until it is deep and has assumed a bluish tint. After heating in water until all the grains are gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* all colored a light, or a light to moderate indigo, and the *solution* a deep indigo. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, most of the *grain-residues* color a light indigo, but in some only the capsules are colored; the *capsules* a reddish violet; and the *solution* a very deep indigo.

Comparison of the *iodine reactions* between *N. madame de graaf* and *N. weardale perfection* shows:

With 0.25 per cent Lugol's solution the grains color less than in *N. weardale perfection* (value 50), and also with 0.125 per cent Lugol's solution. After heating in water until the grains are all gelatinized, the grains color more and the solution less than in *N. weardale perfection.* If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution the grains are colored more than in *N. weardale perfection,* and the capsules red or reddish violet instead of reddish violet as in *N. weardale perfection.*

ANILINE REACTIONS.

With *gentian violet* the grains all color very lightly, at once, and in 30 minutes they are light to moderately colored (value 30). The grains are all equally colored, and there is no variation in different parts of an individual grain.

With *safranin* the grains all color very lightly at once, and in 30 minutes they are light to moderately colored (value 40), more than with gentian violet. The grains are all equally colored, and there is no variation in different parts of an individual grain.

Comparison of the *aniline reactions* between *N. madame de graaff* and *N. weardale perfection* shows:

With *gentian violet* the grains color light to moderately (value 43), much more than *N. weardale perfection.*

With *safranin* the grains color moderately (value 53) much more than *N. weardale perfection.*

TEMPERATURE REACTIONS.

The temperature of gelatinization of the majority of the grains is 68° to 69° C., and of all is 72° to 74° C., mean 73° C.

Comparison of the *temperature reactions* between *N. madame de graaff* and *N. weardale perfection* shows:

The temperature of gelatinization of *N. madame de graaff* is higher, 73.5° to 75° C., mean 74.25° C.

EFFECTS OF VARIOUS REAGENTS.

The reaction with *chloral hydrate* begins in 1 minute. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 7 per cent of the grains and 9 per cent of the total starch in 15 minutes; in about 15 per cent of the grains and 21 per cent of the total starch in 30 minutes; in about 21 per cent of the grains and 28 per cent of the total starch in 45 minutes; and in about 28 per cent of the grains and 33 per cent of the total starch in 60 minutes. (Chart D 323.)

The hilum becomes distinct, accompanied by the formation of a large bubble in a small majority of the grains. The lamellæ are usually not visible, but in a moderate number of grains they can be seen and are moderately distinct. The grains become somewhat more refractive, the first portion to show this increased refractivity is a rather narrow band of starch at the margin. Gelatinization begins at the distal margin and proceeds according to two methods. In the first, which is seen in the majority of the grains, which are also the more resistant grains, gelatinization begins at 1 or 2 points on the distal margin, and after the partial separation of the marginal starch by a circular fissure proceeds around the margin nearly to the proximal margin on either side, then progresses inward, at first preceded by a serial separation of two or three groups of lamellæ, and then by irregular fissuring and splitting off of small fragments of the ungelatinized material; when the hilum is reached it swells suddenly, and the bubble, if present, swells, then shrinks and disappears, and the proximal starch becomes almost hyaline in appearance and is then rapidly gelatinized. In the second method, which is seen in a moderate minority of the more elongated and less resistant grains, gelatinization begins at the distal end and progresses smoothly toward the hilum and proximal end; when the hilum is reached it swells sud-

denly and the bubble if present swells, shrinks, and disappears. The proximal starch becomes hyaline in appearance and then is rapidly gelatinized.

The gelatinized grains are much swollen, have thick capsules, and are much distorted.

Comparison of the *chloral-hydrate* reaction between *N. madame de graaff* and *N. weardale perfection* shows:

A small bubble is less frequently formed at the hilum than in *N. weardale perfection.* The lamellæ are at first not visible, but later become moderately distinct in many more grains than in *N. weardale perfection.* The grains become somewhat more refractive in appearance after the addition of the reagent than in that starch. Gelatinization progresses according to the two methods described under *N. weardale perfection.* In the first, which is observed in a majority of the grains and which is very nearly the same as that seen in an even greater majority of the grains of *N. weardale perfection,* the main differences noted are that gelatinization does not progress around the margin so close to the proximal end, and there is not so much splitting of the grain by fissures or serial separation of groups of lamellæ as in *N. weardale perfection.* In the second method, which is seen in a minority of the grains as in *N. weardale perfection,* the only difference noted is that gelatinization begins at both distal and proximal ends, instead of only at the distal end. The gelatinized grains are more swollen, do not have such thick capsules, and are more distorted than in *N. weardale perfection.*

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 40 per cent of the total starch in 15 minutes; in about 40 per cent of the grains and 91 per cent of the total starch in 30 minutes; in about 91 per cent of the grains and 99 per cent of the total starch in 45 minutes; and in about 99 per cent of the grains and in more than 99 per cent of the total starch in 60 minutes. (Chart D 324.) (See footnote, page 516.)

The hilum becomes distinct, unattended by the formation of a bubble. The lamellæ at first are moderately distinct, but later become very distinct, and traces of a lamellar structure are seen when gelatinization is nearly complete. Gelatinization begins at the hilum and progresses according to two methods. In the first, which is seen in a small majority of the grains, the portion of the grain immediately around the hilum which is not always distinguishable as primary starch is divided into four or five portions by fissures, and these portions are subdivided into rather coarse granules. The rest of the grain is divided by rather fine striæ which gradually grow coarse and very distinct. As the less resistant part of the grain gelatinizes and swells, the more resistant portion forms a coarsely striated and lamellated band at the margin, while the granular material around the hilum is scattered throughout the interior of the grain. The marginal band is often divided by fissures at the proximal and the distal ends, and these portions are gelatinized more rapidly than the rest. The remaining parts become gradually thinner and more homogeneous-looking; finally they are gelatinized and only the capsule is left. Meanwhile the granules in the interior of the grain have been gradually growing smaller and more refractive, but some of them persist after the rest of the grain is completely gelatinized and then disappear very gradually. In the second method 2 furrows or fissures extend from the hilum on either side to the margin and the starch distal to these furrows and to the hilum is fissured and divided into granules which are rather coarse near the hilum and fine in the rest of the grain; only a small rim of marginal starch is left unfissured. This, in connection with a thicker portion at the proximal end, becomes coarsely striated and is the last portion of the grain to be gelatinized. The granular distal material is divided by radiating longitudinal fissures from the hilum and is slowly gelatinized, with considerable swelling of the grain. The starch at the margin is gelatinized even more slowly, first at the distal and then at the proximal end.

The grains are nearly always completely gelatinized before they are dissolved. The gelatinized grains are much swollen, have rather thin capsules, and are not much distorted.

Comparison of the *chromic-acid* reactions between *N. madame de graaff* and *N. weardale perfection* shows:

The hilum and lamellæ are as distinct as in *N. weardale perfection.* Gelatinization progresses according to two methods, which are in general the same as those described under *N. weardale perfection.* The first, which is found in a large majority of the grains, is that which is seen in a small majority of the grains of *N. weardale perfection.* The only differences noted are that there is usually a clear distinction between the primary and the secondary starch; and the granules formed from the primary starch are coarser and more refractive and sometimes remain clumped together in the center of the grain, while the secondary starch is being gelatinized and the grain is swelling. When they do so they are not gelatinized until after the grain has begun to dissolve. In the second method, which is seen in a small minority of these grains and a large minority of those of *N. weardale perfection,* the only difference is that the marginal material at the proximal end only instead of all around the margin forms a resistant band which is gelatinized more slowly than the rest of the grain. Some of the grains are dissolved before gelatinization is complete. The gelatinized grains are more swollen and have thinner capsules, but are no more distorted than in *N. weardale perfection.*

The reaction with *pyrogallic acid* begins in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 37 per cent of the total starch in 15 minutes; in about 54 per cent of the grains and 79 per cent of the total starch in 30 minutes; in about 66 per cent of the grains and 86 per cent of the total starch in 45 minutes; and in about 70 per cent of the grains and 91 per cent of the total starch in 60 minutes. (Charts D 325 and D 326.)

The hilum becomes distinct, unaccompanied by the formation of a bubble. The lamellæ are distinct in all the grains and remain so during the greater part of the reaction. Gelatinization begins at the hilum and proceeds according to two methods. In the first method, which is seen in a small majority of the grains, the starch immediately surrounding the hilum is divided

into a number of rather coarse and refractive granules. The rest of the grain, which probably represents a secondary starch formation, is covered by fine radiating striæ and gelatinization of the less resistant primary and secondary deposit begins. This is accompanied by swelling of the grain. The more resistant secondary material forms a finely striated, lamellated marginal band and the resistant particles of the primary starch are scattered irregularly in the interior of the grain. The marginal band slowly grows thinner and more nearly transparent and the particles in the interior slowly become smaller and more refractive and then disappear. Finally the marginal starch also is gelatinized and only the capsule is left. In the second method, which is seen in a large minority of the grains, two furrows or in some grains actual fissures extend transversely or obliquely from either side of the hilum to the margin and the material distal to them and to the hilum is divided by fine striæ and then by fine, irregularly branching fissures into fine granules, except a narrow band of material at the margin, which in connection with the material at the proximal end and sides nearby forms a finely striated and indistinctly lamellated marginal band. The granular distal starch is gelatinized first and then the distal marginal portion and finally the proximal part.

The gelatinized grains are greatly swollen, have rather thin capsules, and are not much distorted.

Comparison of the *pyrogallic-acid* reactions between *N. madame de graaff* and *N. weardale perfection* shows:

The hilum and the lamellæ are as distinct as in *N. weardale perfection,* and the lamellæ remain distinct for a long time in more grains than that starch. Gelatinization proceeds in general according to two methods described under *N. weardale perfection.* In the first method, which is seen in a large majority of the grains, and which is in general the same as that described for a small majority of the grains of *N. weardale perfection,* the differences noted are that the primary starch is divided into a number of particles which often remain clumped together in the center of the grain, instead of being scattered. The striæ which divide the secondary starch are much finer and less distinct. In the second method which is seen in a small minority of the grains and a large minority of the grains of *N. weardale perfection,* the differences noted are that the material distal to the horizontal fissures and the hilum is not distinctly fissured, but merely loses its structural appearance and becomes a homogeneous-looking refractive mass which is slowly gelatinized. There is not a striated lamellated band all around the margin but only at the proximal end and sides nearby. The gelatinized grains are more swollen, have a thinner capsule, and are more distorted than in *N. weardale perfection.*

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 11 per cent of the total starch in 5 minutes; in about 21 per cent of the grains and 48 per cent of the total starch in 15 minutes; in about 33 per cent of the grains and 57 per cent of the total starch in 30 minutes; in about 39 per cent of the grains and 66 per cent of the total starch in 45 minutes; and in about 42 per cent of the grains and 69 per cent of the total starch in 60 minutes. (Chart D 327.)

The hilum becomes distinct and unaccompanied by the formation of a bubble. The lamellæ are moderately distinct in all the grains and in some of the grains persist throughout the greater part of the reaction. Gelatinization begins at the hilum and proceeds according to two methods. In the first method, which is seen in a small majority, the starch immediately surrounding the hilum, which probably represents the primary starch formation, is divided first into three or four portions, and these are usually in turn divided into a number of rather coarse granules, but in some grains remain as they were after the first division, and as the grain swells retain their original position in the central part of the grain, apparently completely unaffected by the action of the reagent. The secondary starch which surrounds the primary starch is now divided by many rather coarse striæ, and as the less resistant portion of both primary and secondary starch gelatinizes, the grain swells and the more resistant portion of the secondary starch is pushed to the margin, where it forms a distinctly striated and in some grains rather indistinctly lamellated band, around the inner border of which are scattered the granules formed from the primary starch. The marginal band often gelatinizes more rapidly at the distal than at the proximal end of the grain. The granules are more resistant and remain for some time after the rest of the grain is gelatinized. In the second method 2 furrows or in some grains actual fissures extend transversely or obliquely from either side of the hilum to the margin and the material included between them, the hilum and the margin, becomes divided by fissures into irregular granules, except near the margin where they are arranged in two or three rows according to the arrangement of the lamellæ, and then is gelatinized with considerable irregular swelling from the hilum nearly to the distal margin. In the meantime the more resistant starch at the proximal end and sides is divided by rather coarse striæ, and as the grain swells forms, in conjunction with the material of the last two or three lamellæ at the margin of the rest of the grain, a striated, lamellated marginal band which is especially resistant at the proximal end, but which in some grains is finally completely gelatinized. The gelatinized grains are not greatly swollen, the capsule is thick, and they are not greatly distorted, but retain some resemblance to the form of the untreated grain.

Comparison of the *nitric-acid* reactions between *N. madame de graaff* and *N. weardale perfection* shows:

The hilum is as distinct and the lamellæ are more distinct, and remain so during the greater part of the reaction in more grains, than in *N. weardale perfection.* Gelatinization proceeds in general according to the two methods described in *N. weardale perfection,* and that seen in a large majority of the grains is essentially the same as was described for a small majority of the grains of *N. weardale perfection,* the differences noted being that the primary starch is much more apt to remain clumped together in the center of the grain than to be divided into a number of granules which are widely scattered, the striæ which divide the secondary starch are finer and much less distinct, and the marginal band is gelatinized equally slowly in all parts and not less slowly at the distal end as in *N. weardale perfection.* The second method is nearly the same as that described

for a large minority of the grains of *N. weardale perfection,* the differences are that the material distal to the hilum and the transverse furrows or fissures are not distinctly fissured and seem to change gradually into a finely granular mass, of which the separate granules are hardly distinguishable, and there is not a striated lamellated band all around the margin but only at the proximal end and sides nearby. The gelatinized grains are more swollen, have as thin capsules, and are much more distorted than in *N. weardale perfection.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 79 per cent of the entire number of grains and 98 per cent of the total starch in 2 minutes, and in about 98 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 328.)

The hilum becomes distinct, attended by the formation of a small bubble in the majority of the grains. The lamellæ become distinct at first, but are soon obscured. Gelatinization begins at the hilum and progresses according to two methods. In the first, which is seen in a small majority of the grains, the material which represents a primary starch formation and which is immediately around the hilum is either divided into first two and then four portions, which in turn are divided into rather coarse refractive granules; or, after being separated from the rest of the material of the grain, which probably represents a secondary starch formation, by a refractive fissure, remains unaffected until gelatinization is complete, and then is gelatinized as a separate part, the interior becoming granular and the marginal material forming a homogeneous-looking refractive band which is slowly gelatinized. This secondary material surrounding the primary deposit loses its lamellar structure and becomes homogeneous-looking and more refractive, and then is divided into portions of unequal size by concentric refractive fissures. After this it gelatinizes very rapidly, with much swelling and distortion of the capsule. If the primary starch has been divided into coarse granules, these follow closely the swelling of the secondary starch, becoming more and more widely separated as they do so, and at the same time gradually becoming gelatinous. If it is not divided into granules, the primary starch, as already described, gelatinizes as an independent part. In the second method, which is seen in a large minority of grains, two furrows or actual fissures extend transversely or obliquely from the hilum to the margin, and the starch distal to these fissures and to the hilum loses its lamellar structure and becomes homogeneous-looking, and in certain circumscribed portions more refractive. It then gelatinizes rapidly, with much swelling and considerable distortion of the capsule. The starch at the proximal end and sides nearby is meanwhile coarsely striated and, as the grain swells, forms at the proximal margin a coarsely striated band which is comparatively slowly gelatinized after the rest of the grain. The gelatinized grains are much swollen, have rather thin capsules, and are very much distorted.

Comparison of the *sulphuric-acid* reactions between *N. madame de graaff* and *N. weardale perfection* shows:

A bubble is not so often formed at the hilum, and the lamellæ are as distinct as in *N. weardale perfection.* Gelatinization follows in general the two methods described in *N. weardale perfection.* The great majority of the grains follow that seen in a small majority of the grains of *N. weardale perfection,* and the differences are that the primary starch is not divided up into granules, but swells as a separate part at the same time that the secondary starch swells, following this closely; or is first divided by coarse striæ into a number of cylindrical granules which in the same way closely follow the gelatinization and swelling of the secondary starch. Rarely the primary grain remains unaffected until the secondary starch has gelatinized, and then it gelatinizes as an independent grain. In the second method, which is seen in but few of the grains, the differences noted are that the material distal to the hilum and to the furrows extending out from it on either side is divided by concentric refractive fissures which correspond to the lines of the lamellæ and then gelatinized with considerable swelling and distortion, and the proximal starch is not so coarsely striated as in *N. weardale perfection.* The gelatinized grains are more swollen, have thinner capsules, and are more distorted than in *N. weardale perfection.*

Narcissus pyramus (Hybrid).

(Plate 13, fig. 78; Charts D 323 to D 328.)

Histologic Properties.

In *form* the grains are usually simple and isolated. There are as many compound grains and aggregates as in *N. madame de graaff,* and they belong to the same types as in that starch, the compound grains often containing more components than do those of *N. weardale perfection.* There are as many simple grains in which both a primary and a secondary starch formation can be seen, as in *N. madame de graaff,* and more than in *N. weardale perfection.* The grains are as often irregular as in *N. madame de graaff* and the irregularities are due to the same causes. The conspicuous forms are ovoid, elliptical, triangular with rounded corners, and nearly round. The additional forms are plano-convex, lenticular, irregularly quadrilateral, and clam-shell-shaped. The forms are as varied as in *N. madame de graaff* and more varied than in *N. weardale perfection.* In form *N. pyramus* shows a much closer relationship to *N. madame de graaff* than to *N. weardale perfection.*

The *hilum* when not fissured is not very distinct, as in both parents. It is fissured as often as in *N. weardale perfection,* but no more deeply nor extensively than in *N. madame de graaff.* The fissures have the same forms as in the parents. The hilum is sometimes centric, but in the majority of the grains it is eccentric from 0.45 to 0.29, usually 0.37, of the longitudinal axis. In the character and the eccentricity of the hilum *N. pyramus* shows a somewhat closer relationship to *N. madame de graaff* than to *N. weardale perfection.*

The *lamellæ* are usually not distinct, and are rather fine, as in *N. madame de graaff.* In everything else they are the same as in both parents. The number counted on some of the larger grains varies from 8 to 14, usually 10. In the character of the lamellæ *N. pyramus* shows a somewhat closer relationship to *N. madame de graaff* than to *N. weardale perfection,* but there are no marked differences between either parent or hybrid.

In *size* the grains vary from the smaller which are 3 by 3μ, to the larger which are 34 by 40μ and 44 by 44μ, in length and breadth. The common sizes are 18 by 22μ,

22 by 24μ, and 24 by 20μ. In size *N. pyramus* shows a closer relationship to *N. weardale perfection* than to *N. madame de graaff*.

Polariscopic Properties.

The *figure* is not so distinct nor so well defined as in either parent, and in this respect *N. pyramus* is closer to *N. madame de graaff* than *N. weardale perfection*. The lines as in *N. madame de graaff* cross at angles of widely varying size and are more often bent and bisected than in these grains. The figure also more often has the form of a conjugate hyperbola, or of a long line with bisected ends.

The *degree of polarization* varies from low to high (value 42), higher than in *N. madame de graaff*, and there is the same amount of variation in the same aspect of a given grain as in *N. madame de graaff*.

With *selenite* the quadrants are not so well defined and are more irregular in shape than in either parent, and are therefore more like those of *N. madame de graaff* than those of *N. weardale perfection*. The colors are usually not pure, and there are very few with a greenish tinge as in *N. madame de graaff*.

In the character of the figure, the degree of polarization, and the appearances with selenite *N. pyramus* shows a closer relationship to *N. madame de graaff* than to *N. weardale perfection.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate violet tinged with blue (value 55), the same as in *N. weardale perfection* and more than in *N. madame de graaff*. With 0.125 per cent Lugol's solution, the grains all color a light violet, the same as in *N. weardale perfection* and more than in *N. madame de graaff*. After heating in water until the grains are all completely gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* are all colored a light or light to moderate indigo, and the *solution* a deep indigo, as in *N. weardale perfection*. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, most of the *grain-residues* color a light indigo, but in some also the capsules are colored; the *capsules* color a reddish violet, and the *solution* a very deep indigo, as in *N. weardale perfection*. Qualitatively and quantitatively the reactions with iodine show a closer relationship to *N. weardale perfection* than to *N. madame de graaff*.

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes they are light to moderately colored (value 40), much more than in *N. weardale pefection* and somewhat less than in *N. madame de graaff*.

With *safranin* the grains all color very lightly at once, and in 30 minutes they are moderately colored (value 50), much more than in *N. weardale perfection* and somewhat less than in *N. madame de graaff*.

In the reactions with aniline stains *N. pyramus* shows a closer relationship to *N. madame de graaff* than to *N. weardale perfection.*

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 73° to 74° C., and of all is 76° to 77° C., mean 76° C. The temperature of gelatinization of *N. pyramus* is much higher than that of either parent, and is closer to that of *N. madame de graaff* than to that of *N. weardale perfection.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 1 minute. Complete gelatinization occurs in 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 15 per cent of the grains and 19 per cent of the total starch in 30 minutes; in about 16 per cent of the grains and 21 per cent of the total starch in 45 minutes; and in about 23 per cent of the grains and 25 per cent of the total starch in 60 minutes. (Chart D 323.)

The hilum becomes distinct, accompanied by the formation of a bubble in but few grains. The lamellæ are more often visible and more distinct than in either parent. In both these characteristics the hybrid shows a closer resemblance to *N. madame de graaff*. The grains become as refractive after the addition of the reagent as in *N. weardale perfection*. Gelatinization begins at the distal margin and progresses according to the two methods described for both parents. The first, which is seen in a larger majority of the grains than in either parent, is the same as that described under *N. weardale perfection*, and the second, which is seen in a less number of grains, is the same as in both parents.

The gelatinized grains are much swollen, their capsules are not so thick and they are more distorted than in either parent. In these characteristics showing a closer resemblance to *N. madame de graaff*.

In this reaction *N. pyramus* shows qualitatively a somewhat closer relationship to *N. weardale perfection* than to *N. madame de graaff*. The reaction of the two parents and of the hybrid do not show many marked differences.

The reaction with *chromic acid* begins in 30 seconds. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in about 24 per cent of the grains and 64 per cent of the total starch in 15 minutes; in about 64 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 88 per cent of the grains and 99 per cent of the total starch in 45 minutes; and in about 97 per cent of the grains and in more than 99 per cent of the total starch in 60 minutes. (Chart D 324.) (See footnote, page 516.)

The hilum and lamellæ are as distinct as in both parents. Gelatinization begins at the hilum and progresses according to the two methods which are observed in both parents. The first method is seen in a large majority of the grains and is the same as that in a large minority of the grains of *N. weardale perfection*, and similar to that noted in a small minority of the grains of *N. madame de graaff*. The second method resembles that seen in a small majority of the grains of *N. weardale perfection*. The differences noted are that the primary starch is divided into coarser and more refractive granules as in *N. madame de graaff*, and the striæ dividing the secondary starch are not so coarse nor so distinct.

The grains as in *N. weardale perfection* are always completely gelatinized before they are dissolved. The

gelatinized grains are as much swollen, have as thin capsules and are no more distorted than in *N. weardale perfection.*

In this reaction *N. pyramus* shows qualitatively a closer relationship to *N. weardale perfection* than to *N. madame de graaff.*

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 13 per cent of the grains and 50 per cent of the total starch in 15 minutes; in 35 per cent of the grains and 80 per cent of the total starch in 30 minutes; in about 58 per cent of the grains and 88 per cent of the total starch in 45 minutes; and in about 72 per cent of the grains and 91 per cent of the total starch in 60 minutes. (Charts D 325 and D 326.)

The hilum and lamellæ are as distinct as in both parents. Gelatinization begins at the hilum and proceeds according to two methods. The method which is noted in a small majority of the grains is the same as that seen in a large minority of the grains of *N. weardale perfection,* and is similar to that found in a small minority of the grains of *N. madame de graaff.* The second method, which is observed in a small minority of the grains, resembles that seen in a small majority of the grains of *N. weardale perfection;* the differences noted are that the primary starch is divided into coarser and more refractive granules, and the striæ in the secondary starch are finer and not so distinct. The gelatinized grains are as much swollen, have rather thick capsules, and are as much distorted as in *N. weardale perfection.*

In this reaction *N. pyramus* shows qualitatively a closer relationship to *N. weardale perfection* than to *N. madame de graaff.*

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 18 per cent of the total starch in 5 minutes; in about 14 per cent of the grains and 54 per cent of the total starch in 15 minutes; in about 32 per cent of the grains and 63 per cent of the total starch in 30 minutes; in about 39 per cent of the grains and 70 per cent of the total starch in 45 minutes; and in about 45 per cent of the grains and 75 per cent of the total starch in 60 minutes. (Chart D 327.)

The hilum and lamellæ are as distinct as in *N. madame de graaff.* Gelatinization begins at the hilum and proceeds according to two methods, as in both parents. The first method in a small majority of the grains is the same as that noted in a large minority of the grains of *N. weardale perfection.* The method seen in a large minority of the grains is nearly the same as that described for a small majority of the grains of *N. weardale perfection;* the main differences noted are that the primary starch is not divided into such fine particles, and the striæ which appear in the secondary starch are rather fine and not so distinct as in *N. weardale perfection.* The gelatinized grains are as much swollen, have as thick capsules, and are as distorted as in *N. weardale perfection.*

In this reaction *N. pyramus* shows a closer relationship to *N. weardale perfection* than to *N. madame de graaff.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 91 per cent of the entire number of grains and 99 per cent of the total starch in 2 minutes; and in about 99 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 329.)

The hilum becomes as distinct, attended by the formation of a small bubble, in as many grains as in *N. weardale perfection,* and the lamellæ are as distinct as in both parents. Gelatinization begins at the hilum and proceeds as in both parents. The method which is seen in a small majority of the grains is the same as that seen in a large minority of the grains of *N. weardale perfection,* and is similar to that seen in a small minority of the grains of *N. madame de graaff.* The method which is seen in a small minority of the grains is nearer that noted in a large majority of the grains of *N. madame de graaff,* rather than that found in a small majority of the grains of *N. weardale perfection,* as the primary starch is less apt to be broken into granules or to remain intact and gelatinize after the gelatinization of the secondary starch. Both of these methods of gelatinization are, however, seen in rare grains. The gelatinized grains are as much swollen, have as thin capsules, and are as distorted as in *N. weardale perfection.*

In this reaction *N. pyramus* shows qualitatively a closer relationship to *N. weardale perfection* than to *N. madame de graaff.*

22. Starches of Narcissus monarch, N. madame de graaff, and N. lord roberts.

Starch of *Narcissus madame de graaff* is described on pages 570 to 572.

Narcissus monarch (Seed Parent).

(Plate 14, fig. 79; Charts D 329 to D 334.)

Histologic Properties.

In *form* the grains are usually simple and isolated, but there is a moderate number of compound grains and a few aggregates. The compound grains belong to two types: (1) 2 small grains each consisting of a hilum and 2 or 3 lamellæ surrounded by 4 or 5 common secondary lamellæ; (2) 6 to 8 or 9 hila in an amorphous-appearing mass of starch which is surrounded by 1 or 2 secondary lamellæ. The aggregates consist of 2, 3, or 4 small grains, usually linearly, but sometimes compactly, arranged. A minority of the simple grains show a primary and a secondary period of starch formation. The majority of the grains are somewhat irregular, and the irregularities are due to the following causes: (1) Small and large, irregular elevations and depressions in the surfaces and margins of the grains; (2) large and small pointed and rounded protuberances from the ends or the sides of the grain; (3) greater development of one part of the distal end or of one side; (4) 2 depressions of equal or unequal size in either side of the proximal apex. The conspicuous forms are ovoid, lenticular, nearly round, elliptical, and triangular with rounded angles. The additional forms are plano-convex, dome-shaped, irregularly quadrilateral, pyriform, and gourd-shaped. Some of the broad forms are flattened, but most of the grains are not.

The *hilum* when not fissured is a rather indistinct small, round or, rarely, lenticular spot. It is fissured in the great majority of the grains, but not deeply nor

extensively. The fissures have the following forms: (1) A single straight or curved transverse, oblique, or, rarely, longitudinal line; (2) Y, T, V, and cruciate forms; (3) flying-bird forms; (4) an irregularly stellate arrangement of several fissures. The hilum is sometimes centric, but it is usually eccentric from 0.45 to 0.3, usually 0.33, of the longitudinal axis.

The *lamellæ* are usually not visible, but can be seen rather indistinctly in some grains and appear as rather coarse continuous rings which have, in general, the form of the outline of the grain. They are more easily seen near the hilum than near the margin. The number could not be determined.

In *size* the grains vary from the smaller which are 3 by 3μ, to the larger which are 32 by 46μ, in length and breadth. The common sizes are 22 by 32μ and 32 by 24μ.

Comparison of the *histologic properties* between *N. madame de graaff* and *N. monarch* shows:

There are more aggregates and fewer compound grains, and the compound grains, while belonging in general to the same two types, often have more components than those of *N. monarch*. There are more simple grains which show a primary and a secondary period of starch formation. The grains are somewhat more irregular in form, and the irregularities are due to the same causes with addition of irregularly placed pressure facets. The forms are as varied as in *N. monarch*.

The *hilum* is less often fissured, and the fissures are no more deep or extensive than in *N. monarch*. The fissures have the same forms. The hilum is usually somewhat less eccentric, the common degree of eccentricity being 0.37 of the longitudinal axis.

The *lamellæ* are more often visible and are somewhat more distinct. They are also not so coarse as in *N. monarch*.

In *size* the grains are not quite so large, the common sizes being 20 by 24μ, 24 by 24μ, and 30 by 24μ.

Polariscopic Properties.

The *figure* is often not distinct and never well defined. The lines cross at angles of widely varying size, and are very often bent and moderately often bisected. There are also a number of figures which have the form of a conjugate hyperbola, or of a long line with bisected ends.

The *degree of polarization* varies from low to high (value 40). There are very few grains in which it is high, and a large majority in which it is low or moderate. There is considerable variation in a given aspect of the same grain.

With *selenite* the quadrants are not clean-cut, and are unequal in size and often irregular in shape. The colors are not pure, and there are a very few which have a greenish tinge.

Comparison of the *polariscopic properties* between *N. madame de graaff* and *N. monarch* shows:

The figure is more distinct and sometimes well defined. The lines do not cross at angles of such widely varying size and are not so often bent or bisected. There are fewer figures which have the form of a conjugate hyperbola, or of a long line bisected at both ends.

The *degree of polarization* is somewhat lower (value 37), as there are more grains in which it is low and fewer in which it is moderate.

With *selenite* the quadrants are more often clean-cut, and are not so often irregular in form. The colors are not pure, and there is the same number of grains which have a greenish tinge.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate violet with a very slight bluish tinge (value 50). The color deepens with moderate rapidity until it is very deep, at the same time assuming a more bluish tint. With 0.125 per cent Lugol's solution the grains all color a light violet, and the color deepens with moderate rapidity until the grains are deeply colored and the color has assumed a somewhat bluish tint. After heating in water until all the grains are completely gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* all color an indigo-blue and the *solution* an indigo-blue. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the *grain-residues* all color a light indigo, the *capsules* a red or reddish violet, and the *solution* a very deep indigo.

Comparison of the *iodine reactions* between *N. madame de graaff* and *N. monarch* shows:

With 0.25 and 0.125 per cent Lugol's solution the grains all color the same as in *N. monarch*. After heating in water until the grains are all gelatinized, the grains color a moderate indigo and the solution a deep indigo as in *N. monarch*. After boiling for 2 minutes, the grain-residues, the capsules, and the solution color as in *N. monarch*.

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes they are moderately colored (value 45). The grains are all equally deeply colored, and there is no variation in the depth of the color in different parts of the same grain.

With *safranin* the grains all color very lightly at once, and in 30 minutes they are moderately colored (value 50), more than with gentian violet. The grains are all equally deeply colored, and there is no variation in depth of the color in different parts of the same grain.

Comparison of the *aniline reactions* between *N. madame de graaff* and *N. monarch* shows:

With *gentian violet* the grains are light to moderately colored (value 43) somewhat less than in *N. monarch*.

With *safranin* the grains are moderately colored (value 53), somewhat more than *N. monarch*.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 67° to 68.5° C., and of all is 72° to 73° C., mean 72.5° C.

Comparison of the *temperature reactions* between *N. madame de graaff* and *N. monarch* shows:

The temperature of gelatinization is somewhat higher, 73.5° to 75° C., mean 74.25° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 2 minutes. Complete gelatinization occurs in 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 10 per cent of the total starch in 15 minutes; in about 14 per cent of the grains and 18 per cent of the

total starch in 30 minutes; in about 16 per cent of the grains and 20 per cent of the total starch in 45 minutes; and in about 18 per cent of the grains and 23 per cent of the total starch in 60 minutes. (Chart D 329.)

The hilum becomes distinct, accompanied by the formation of rather large bubbles in very few grains. The lamellæ are not visible in most of the grains, but in a few become moderately distinct. The grains become considerably more refractive after the addition of the reagent, and the first part of the grains to be so affected is a broad band of material at the margin. Gelatinization begins at 2, 3, or 4 discrete points on the distal margin and progresses according to two methods. In the first, which is seen in the great majority of the grains, which are also the more resistant, gelatinization proceeds from the initial points around the margin until all the marginal starch is gelatinized, except a narrow strip at the proximal end. Then it progresses inward preceded by irregular cracks and fissures which split off particles of ungelatinized material, until the main portion of the ungelatinized grain assumes an angular instead of a rounded appearance. The proximal deposit is usually gelatinized before the portion of the grain immediately surrounding the hilum, which when the rest of the grain has been gelatinized is split into two portions which are widely separated, and gelatinize independently of one another. If a bubble is present at the hilum when this splitting occurs it first swells, then shrinks, and disappears. In the second method which occurs in rather a small minority of the grains which are also the less resistant, gelatinization begins at the distal end and then at the proximal end, and advances smoothly from these two points. The last portion of the grain to be gelatinized is that immediately distal to the hilum, and this, just before gelatinization occurs, is sometimes split into two portions which are widely separated, and gelatinize independently of one another. The gelatinized grains are much swollen have rather thick capsules and are considerably distorted.

Comparison of the *chloral-hydrate* reaction between *N. madame de graaff* and *N. monarch* shows:

A bubble is formed at the hilum in more grains than in *N. monarch*. The lamellæ are visible in many more grains and are moderately distinct when they are visible, as in *N. monarch*. The grains do not become so refractive after the addition of the reagent. Gelatinization progresses according to two methods, which are in general the same as those described under *N. monarch*. In the first method, which is seen in a smaller majority of the grains than in *N. monarch,* the points of difference to be noted are that the whole margin up to a narrow strip at the proximal end is not gelatinized, but only the distal margin, and the progress of gelatinization toward the hilum is accompanied by the serial separation of groups of lamellæ, and the material at the proximal end is the last portion of the grains to be gelatinized instead of that just distal to the hilum. No differences are noted in the second method.

The gelatinized grains are more swollen, do not have such thick capsules, and are more distorted than in *N. monarch*.

The reaction with *chromic acid* begins in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 33 per cent of the total starch in 5 minutes; in about 28 per cent of the grains and 71 per cent of the total starch in 15 minutes; in about 66 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 90 per cent of the grains and in more than 99 per cent of the total starch in 45 minutes; and in about 95 per cent of the grains and in more than 99 per cent of the total starch in 60 minutes. (Chart D 330.) (See footnote, page 516.)

The hilum becomes distinct, unattended by the formation of a bubble. The lamellæ are at first not very distinct, but later become distinct. Evidences of a lamellar structure do not persist until near the end of the reaction, as in some of the starches studied. Gelatinization begins at the hilum and progresses according to two methods. In the first, which is seen in a majority of the grains, the portion of the grain immediately surrounding the hilum and which in some grains can be clearly seen to be a primary starch formation, is cracked into 3 to 5 pieces, which are in turn subdivided into 8 or 9 more smaller portions. The secondary starch is covered with rather fine striæ, and as the less resistant part is gelatinized and the grain swells, the more resistant portion forms a rather finely striated marginal band which at first sometimes shows a lamellar structure; but which as gelatinization goes on becomes thinner and more and more homogeneous in appearance. The particles of the primary starch are scattered irregularly in the interior of the grain and often some remain ungelatinized until after solution begins. The distal portion of the marginal band is often gelatinized and dissolved before gelatinization of the proximal end. In the second method, which is seen in a minority of the grains, two furrows or fissures extend transversely or obliquely from the hilum on either side to the margin and the material distal to them and to the hilum is divided into very fine granules, and this granular mass in turn is divided very irregularly by branching longitudinal fissures from the hilum. As this portion of the grain is slowly gelatinized with considerable swelling of the grain, the proximal material, which has been divided by rather fine striæ, forms a striated band at the proximal end, which is not gelatinized until after the distal portion. The capsule at the distal end is often dissolved before gelatinization is complete, and the contents of the capsule flow out and are dissolved, the proximal material being the last. About half the grains are dissolved before gelatinization is complete. The gelatinized grains are much swollen, have thin capsules, and are not greatly distorted.

Comparison of the *chromic-acid* reaction between *N. madame de graaff* and *N. monarch* shows:

The hilum and lamellæ are as distinct as in *N. monarch*. Gelatinization progresses according to two methods, which are very similar to the two described under *N. monarch*. The first is seen in a larger majority of the grains than in *N. monarch,* and the differences noted are that the primary deposit is more apt after division to remain clumped in the interior of the grain, and the striæ which divide the secondary starch are not so fine and are more distinct than in *N. monarch.* In the second method, which is seen in a smaller minority of the grains than in *N. monarch,* there are no important differences, except that the material distal to the

two furrows or fissures from the hilum is divided into rather coarse and more refractive granules than in *N. monarch*.

Fewer grains than in *N. monarch* are dissolved before gelatinization is complete. The gelatinized grains are more swollen, have thinner capsules, and are somewhat more distorted than in *N. monarch*.

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in about 28 per cent of the grains and 56 per cent of the total starch in 15 minutes; in about 50 per cent of the grains and 72 per cent of the total starch in 30 minutes; in about 58 per cent of the grains and 82 per cent of the total starch in 45 minutes; and in about 68 per cent of the grains and 86 per cent of the total starch in 60 minutes. (Charts D 331 and D 332.)

The hilum becomes distinct, unattended by the formation of a bubble in any of the grains. The lamellæ are distinct, and evidence of a lamellar structure persists in most of the grains until they are almost completely gelatinized. Gelatinization begins at the hilum and progresses according to two methods. In the first, which is seen in the majority of the grains, the starch immediately around the hilum, which probably represents the primary formation, is divided into four or five portions, which are in turn subdivided. These several particles, however, remain clumped together as the rest of the grain gelatinizes. The secondary starch surrounding them becomes homogeneous-looking and more refractive, and as gelatinization of the less resistant portion begins and the grain begins slowly to swell, the more resistant portion is pushed to the margin, where it forms a thick, refractive marginal band which shows two or three rings as lamellæ around it. This band gradually grows thinner and more nearly transparent until finally it is gelatinized and only the capsule remains. The particles of the primary starch meanwhile remain in the center of the grain, growing smaller and more refractive until they also are gelatinized. In the second method, which is seen in a minority of the grains, two furrows or fissures extend transversely or rarely obliquely on either side from the hilum to the margin, and the starch distal to them and to the hilum becomes more refractive and loses its structural appearance, except at the margin, which, in connection with the portion at the proximal end, forms a finely striated and indistinctly lamellated marginal band. The homogeneous-looking material in the interior of the grain is gelatinized first with slow swelling of the grain and then of the marginal band, the distal portion first, and last of all the proximal part. The gelatinized grains are much swollen, have somewhat thick capsules, and are considerably distorted.

Comparison of the *pyrogallic-acid* reaction between *N. madame de graaff* and *N. monarch* shows:

The hilum and lamellæ are not so distinct, and evidence of lamellar structure is not so persistent as in *N. monarch*. Gelatinization proceeds according to two methods. That in the majority of the grains corresponds to the one described for a majority of the grains of *N. monarch*, the main differences being that the primary starch is less apt to remain clumped together, and striæ appearing in the secondary starch are moderately distinct. In the second method the differences noted are that the starch distal to the hilum and the furrows becomes definitely granular and there is not a continuous band around the margin, but only at the proximal end and sides nearby, the striation of which is more distinct, but the lamellation is less distinct, than in *N. monarch*. The gelatinized grains are more swollen, have thin capsules, and are more distorted, than in *N. monarch*.

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 20 per cent of the total starch in 5 minutes; in about 28 per cent of the grains and 64 per cent of the total starch in 15 minutes; in about 36 per cent of the grains and 72 per cent of the total starch in 30 minutes; in about 48 per cent of the grains and 78 per cent of the total starch in 45 minutes; and in about 56 per cent of the grains and 84 per cent of the total starch in 60 minutes. (Chart D 333.)

The hilum is distinct and a bubble is occasionally formed there immediately after the reagent is added, which, however, soon shrinks and disappears. The lamellæ are distinct, and evidence of a lamellar structure persists until the grains are almost completely gelatinized. Gelatinization begins at the hilum and follows two methods of procedure. In the first, which occurs in the majority of the grains, the starch immediately around the hilum, which probably represents the primary formation, is divided by a longitudinal fissure into halves and these in turn into two or three pieces, which, however, as a rule, remain clumped together during the gelatinization of the rest of the grain. In some grains this primary starch after the initial splitting remains unchanged, but in the majority the pieces are slightly separated and become more refractive in appearance and smaller in size until, some time after the rest of the grain is gelatinized, they also are completely gelatinized. The portion of the grain which surrounds the primary starch and probably represents a secondary starch formation becomes indistinctly striated, and as the less resistant material is gelatinized with swelling of the whole grain, the more resistant starch is pushed to the margin, where it forms a lamellated but otherwise homogeneous-looking band which slowly becomes thinner and more nearly transparent. The lamellated appearance persists until nearly the entire grain is gelatinized. In the second method of procedure 2 furrows or fissures extend transversely or obliquely on either side from the hilum to the margin, and the material included between them becomes more refractive in appearance and the lamellar structure disappears, leaving in its stead a finely granular mass. This part of the grain gelatinized first with considerable swelling and distortion of the capsule. The more resistant portion at the proximal end is pushed to the margin and then forms a band which is lamellated but not striated and which extends only to the sides near the proximal end. This slowly becomes thinner and more nearly transparent until only the capsule remains.

The gelatinized grains are much swollen and have somewhat thick capsules. They are considerably distorted and do not show much resemblance to the forms of the untreated grain.

Comparison of the *nitric-acid* reactions between *N. madame de graaff* and *N. monarch* shows:

The hilum and lamellæ are not so distinct, and evidences of a lamellar structure are not so persistent as in *N. monarch*. Gelatinization proceeds according to two methods. That seen in the majority of the grains corresponds in all essentials to that found in a majority of the grains of *N. monarch;* the differences noted are that the particles of the primary starch are somewhat less apt to remain clumped together as the rest of the grain swells. The striæ which divide the secondary starch are more distinct, and the lamellation less distinct, than in *N. monarch*. The second method corresponds to that seen in a minority of the grains of *N. monarch* and the differences are that the material distal to the 2 furrows and the hilum is more definitely granular and the striation of the material at the proximal end is more definite, while the lamellation is less so. The gelatinized grains are more swollen, have thin capsules, and are more distorted than in *N. monarch*.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 90 per cent of the entire number of grains and 96 per cent of the total starch in 2 minutes, and in more than 99 per cent of the grains and total starch in 5 minutes. (Chart D 334.)

The hilum becomes distinct, accompanied by the formation of a rather small bubble in a moderate number of grains, and the lamellæ are not distinct at first, but during the reaction become more distinct. Gelatinization begins in the interior of the grain and progresses according to two methods. In the great majority of the grains two furrows or fissures are seen to extend transversely from the hilum on either side to the margin, and the portion which is immediately around the hilum and which is a primary starch formation is partially divided from the rest of the starch distal to the furrows, which is a secondary starch formation by a fissure. The secondary starch distal to the furrow is now divided into portions by concentric fissures which separate the lamellæ from one another. The secondary starch now gelatinizes with much swelling and distortion of the capsule and the primary starch gelatinizes also from without inward, the last part to be gelatinized being the hilum. The portion of the secondary starch proximal to the furrows meanwhile is not gelatinized, and as the grain swells forms a homogeneous-looking band at the proximal margin. This, after the rest of the grain is completely gelatinized, gelatinizes slowly. The second method is the same as the first, except that there is no distinction between the primary and secondary starches, and the whole grain is gelatinized, as is the secondary starch, by the first method. The gelatinized grains are much swollen, have rather thin capsules, and are considerably distorted.

Comparison of the *sulphuric-acid* reactions between *N. madame de graaff* and *N. monarch* shows:

A bubble is formed at the hilum somewhat more frequently than in *N. monarch*, and the lamellæ are somewhat more distinct at first than in that starch. Gelatinization progresses according to two methods. The first, which is seen in a large majority of the grains, does not resemble closely either of the methods described in *N. monarch*. The grains are divided into primary and secondary starches. The primary starch may become homogeneous in appearance or be divided into cylindrical granules and is gelatinized as a separate part at the same time that the secondary starch is gelatinized, instead of later as in *N. monarch*. The secondary starch, however, as in *N. monarch,* is divided by concentric fissures into portions corresponding to the lamellæ preliminary to gelatinization. The second method is the same as the second method described in *N. monarch*. The gelatinized grains are more swollen, have thinner capsules, and are more distorted, than in *N. monarch*.

NARCISSUS LORD ROBERTS (HYBRID).

(Plate 14, fig. 81; Charts D 329 to D 334.)

HISTOLOGIC PROPERTIES.

In *form* the grains are usually simple and isolated, but there are as many aggregates and more compound grains than in *N. monarch,* and many more than in *N. madame de graaff*. The compound grains belong to the two types, and the aggregates are of the same character, as those described under *N. monarch*. The grains are as seldom irregular and the irregularities are due to the same causes as in *N. monarch*. There is a smaller number of simple grains than in either parent which give evidence of a primary and a secondary period of starch formation, in which respect the hybrid is closer to *N. monarch*. The conspicuous forms are ovoid, plano-convex, triangular, and lenticular. The additional forms are irregularly quadrilateral, elliptical, clam-shell-shaped, dome-shaped, and pyriform. In form *N. lord roberts* shows a closer relationship to *N. monarch* than to *N. madame de graaff*.

The *hilum,* when not fissured, is not very distinct, as in *N. monarch,* and it is more often and more deeply and extensively fissured than in either parent, and, therefore, in this respect resembles *N. monarch* more than *N. madame de graaff*. The fissures have the following forms: (1) T-, Y-, and V-shaped, and cruciate forms; (2) a single straight or curved transverse, oblique, or longitudinal line; (3) a flying-bird form; (4) an irregularly stellate collection of fissures. The hilum is sometimes centric, but in the majority of the grains it is eccentric from 0.45 to 0.3, usually 0.33, of the longitudinal axis. In the character and eccentricity of the hilum *N. lord roberts* shows a closer relationship to *N. monarch* than to *N. madame de graaff*.

The *lamellæ* are visible in as many grains and are as distinct and as fine as in *N. madame de graaff*. The number counted on some of the larger grains varies from 8 to 16, usually 12. In the character of the lamellæ *N. lord roberts* shows a closer relationship to *N. madame de graaff* than to *N. monarch*.

In *size* the grains vary from the smaller which are 4 by 4μ, to the larger which are 36 by 46μ, in length and breadth. The common sizes are 24 by 26μ, 30 by 24μ, and 24 by 24μ. In size *N. lord roberts* shows a closer relationship to *N. madame de graaff* than to *N. monarch*.

POLARISCOPIC PROPERTIES.

The *figure,* as in *N. monarch,* is often not distinct and is never well defined. The lines cross at angles of widely varying size, and are somewhat less often bent and bisected than in *N. monarch,* but as often as in *N. madame de graaff*. The figure is as often in the form of a conjugate hyperbola, or of a long line bisected at both ends, as in *N. madame de graaff*.

The *degree of polarization* varies from low to high (value 37), the same as *N. madame de graaff,* and less

than *N. monarch*. There is the same amount of variation in a given aspect of an individual grain as in *N. madame de graaff*.

With *selenite* the quadrants are not clean-cut and are as irregular in shape as in *N. madame de graaff*. The colors are not pure and there are as few grains with a greenish tinge as in that starch.

In the character of the figure, the degree of polarization, and the appearance with selenite, *N. lord roberts* shows a somewhat closer relationship to *N. madame de graaff* than to *N. monarch*.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate violet tinged with blue (value 50), the same as in both parents, but with the same bluish tint as in *N. madame de graaff* and more than in *N. monarch*. With 0.125 per cent Lugol's solution the grains all color a light violet, the same as in both parents. After heating in water until the grains are all gelatinized, then treating with a 2 per cent Lugol's solution, the gelatinized *grains* all color a moderate indigo and the *solution* a deep indigo, as in both parents. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the *grain-residues* all color a light indigo, the *capsules* a red or a reddish violet, and the *solution* a very deep indigo-blue, as in both parents. Qualitatively and quantitatively the reactions with iodine show no differences between the parents and the hybrid.

With *gentian violet* the grains color very lightly at once, and in 30 minutes they are moderately colored (value 45), the same as in *N. monarch* and more than in *N. madame de graaff*.

With *safranin* the grains all color very light at once, and in 30 minutes they are moderately colored (value 50), the same as in *N. monarch* and somewhat less than in *N. madame de graaff*.

In the reactions with aniline stains *N. lord roberts* shows a somewhat closer relationship to *N. monarch* than to *N. madame de graaff*.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 68° to 69.4° C., and of all is 73° to 74.5° C., mean 73.75° C. The temperature of gelatinization of *N. lord roberts* is slightly closer to that of *N. madame de graaff*, but stands very nearly midway between those of *N. monarch* and *N. madame de graaff*.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 1 minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 11 per cent of the total starch in 15 minutes; in about 12 per cent of the grains and 20 per cent of the total starch in 30 minutes; in about 23 per cent of the grains and 27 per cent of the total starch in 45 minutes; and in about 25 per cent of the grains and 29 per cent of the total starch in 60 minutes. (Chart D 329.)

The hilum becomes distinct, accompanied by the formation of a large bubble, in as few grains as in *N. monarch*. The lamellæ are not visible in any of the grains. After the addition of the reagent the grains become as refractive as in *N. monarch* and more refractive than in *N. madame de graaff*. Gelatinization begins at the distal end and progresses according to the two methods described under both parents. The first method, which is seen in as large a majority as in *N. monarch,* is the same as in that starch, except in a few grains in which it is the same as in *N. madame de graaff*. In the second method, which is seen in as small a minority of the grains as in *N. monarch,* there are no differences noted in the hybrid or either parent.

The gelatinized grains are as much swollen, have as thick capsules, and are as much distorted as in *N. madame de graaff*.

In this reaction *N. lord roberts* shows qualitatively a somewhat closer relationship to *N. monarch* than to *N. madame de graaff*.

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the grains and 1 per cent of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 15 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 50 per cent of the total starch in 30 minutes; in about 20 per cent of the grains and 72 per cent of the total starch in 45 minutes; and in about 25 per cent of the grains and 88 per cent of the total starch in 60 minutes. (Chart D 330.) (See footnote, page 516.)

The hilum and lamellæ are as distinct as in both parents. Gelatinization begins at the hilum and progresses according to the two methods described in both parents. The method which is seen in a small majority of the grains is the same as that described for a much larger majority of the grains of *N. madame de graaff* and a somewhat larger majority of the grains of *N. monorch*. In a large minority of the grains the method is the same as that described for a small minority of the grains of *N. madame de graaff*. About half the grains are dissolved before gelatinization is complete, as in *N. monarch*. The gelatinized grains are as much swollen, have as thin capsules, and are no more distorted than in *N. monarch*. In this reaction *N. lord roberts* shows qualitatively a somewhat closer relationship to *N. madame de graaff* than to *N. monarch*.

The reaction with *pyrogallic acid* begins in 2 minutes. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 36 per cent of the total starch in 15 minutes; in about 23 per cent of the grains and 63 per cent of the total starch in 30 minutes; in about 33 per cent of the grains and 73 per cent of the total starch in 45 minutes; and in about 47 per cent of the grains and 83 per cent of the total starch in 60 minutes. (Charts D 331 and D 332.)

The hilum and lamellæ are as distinct as in *N. madame de graaff*. Gelatinization begins at the hilum and follows the two methods of procedure common to both parents. The method described for a majority of the grains of both parents is seen in a small majority of these grains, in which it follows very closely that seen in *N. madame de graaff* rather than that seen in *N. monarch*. In a large minority of the grains the method is the same as that described for a small minority of the grains of *N. madame de graaff*. The gelatinized grains are as

swollen, have as thick capsules, and are as distorted as in *N. monarch*. In this reaction *N. lord roberts* shows qualitatively a somewhat closer relationship to *N. madame de graaff* than to *N. monarch*.

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 31 per cent of the grains and 62 per cent of the total starch in 15 minutes; in about 42 per cent of the grains and 70 per cent of the total starch in 30 minutes; in about 47 per cent of the grains and 73 per cent of the total starch in 45 minutes; and in about 50 per cent of the grains and 76 per cent of the total starch in 60 minutes. (Chart D 333.)

The hilum is distinct as in the parents, and the lamellæ are at first more distinct than in either parent, but evidence of a lamellar structure is no more persistent than in *N. madame de graaff*. Gelatinization begins at the hilum and follows two methods of procedure, as described in *N. monarch* and noted in both parents. The method described for the majority of the grains of *N. monarch* is followed in a small majority of these grains, but in a manner corresponding to that of the grains of *N. madame de graaff*, and a large minority follow very closely the method described for a small minority of the grains of *N. madame de graaff*. The gelatinized grains are as swollen and have as thick a capsule and are as much distorted as in *N. monarch*.

In this reaction *N. lord roberts* shows qualitatively a somewhat closer relationship to *N. madame de graaff* than to *N. monarch*.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 82 per cent of the entire number of grains and 95 per cent of the total starch in 2 minutes, and in about 95 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 334.)

The hilum as in *N. monarch* becomes distinct, attended by the formation of a bubble in a moderate number of grains. The lamellæ are usually not distinct at first, but become as distinct as in the parents during the reaction. Gelatinization begins in the interior of the grains and progresses according to the two methods described under *N. monarch*, the only difference noted being that there is a larger minority of the grains that follows the second method, which is seen in a small minority of the grains of both *N. monarch* and *N. madame de graaff*. The first method is not found in any of the grains of *N. madame de graaff*. The gelatinized grains are as much swollen, have as thin capsules, and are as much distorted as in *N. monarch*. In this reaction *N. lord roberts* shows, qualitatively, a closer relationship to *N. monarch* than to *N. madame de graaff*.

23. Starches of N. leedsii minnie hume, N. triandrus albus, and N. agnes harvey.

Narcissus leedsii minnie hume (Seed Parent).

(Plate 14, fig. 82; Charts D 335 to D 340.)

Histologic Properties.

In *form* the grains are usually simple and isolated, but there are moderate numbers of both compound grains and aggregates. The compound grains belong to the following two types: (1) A large grain to the side or distal end of which 1, rarely 2, small grains have become adherent, and all later inclosed in 1 or 2 common secondary lamellæ; (2) 2 or more small grains which have become adherent to one another, and all later surrounded by 3 or 4 common secondary lamellæ. The aggregates consist of 2 or 3 small grains of equal sizes, usually linearly arranged. There are a few of the simple grains which show clearly that they have been formed in two periods of starch formation, and have a small primary grain surrounded by 3 or 4 secondary lamellæ. The grains are somewhat irregular, and the irregularities are due to the following causes: (1) Small, irregular elevations and depressions of the surfaces and margins; (2) 1 or 2 protuberances of varying size which are usually pointed; (3) a slight deviation of the long axis, usually near the middle, with a consequent bending of the grain. The conspicuous forms are ovoid, elliptical, triangular with rounded bases and angles, and plano-convex. The additional forms are irregularly quadrilateral with rounded angles, round and nearly round, and reniform. Some of the broad forms are somewhat flattened, the others are not.

The *hilum*, when not fissured, is a moderately distinct, small, round or lenticular spot. It is usually fissured but not deeply or extensively. The fissures have the following forms: (1) A single straight, transverse, oblique, or longitudinal line; (2) Y, T, V, or cruciate forms; (3) dragon-fly or flying-bird-shaped; (4) an irregularly stellate collection of fissures. The hilum is sometimes centric, but in the majority of the grains it is eccentric from 0.45 to 0.25, usually 0.33, of the longitudinal axis.

The *lamellæ* are moderately distinct in most of the grains, especially near the hilum, but are not visible in a few grains. They are rather fine, regular, continuous rings which follow, in general, the form of the outline of the grain. The number counted on some of the larger grains varies from 10 to 15, usually 12.

In *size* the grains vary from the smaller which are 3 by 3μ, to the larger broad forms, which are 48 by 50μ and 44 by 44μ, and the larger elongated forms which are 44 by 36μ, in length and breadth. The common sizes are 28 by 26μ and 28 by 28μ.

Polariscopic Properties.

The *figure* is usually distinct and moderately well defined. The lines usually cross at an acute angle, which does not vary greatly in size in the different grains, and they are often bent and occasionally bisected, and there are sometimes 5 or 6 lines instead of but 4. The figure, in a moderate number of grains, has the form of a conjugated hyperbola, or of a long line bisected at both ends.

The *degree of polarization* varies from low to high (value 45), and in most of the grains is moderate or low to moderate. There is usually some variation in a given aspect of an individual grain.

With *selenite* the quadrants are moderately clean-cut, and are unequal in size, and often irregular in shape. The colors are usually not pure, and there are a few which have a greenish tinge.

Iodine Reactions.

With 0.25 per cent Lugol's solution, the grains all color a moderately deep violet tinged with blue (value 60), and the color deepens rapidly until the grains are all

very deeply colored and the color has assumed more of a bluish tint. With 0.125 per cent Lugol's solution the grains all color a light to moderate violet, deepening rapidly until deep and bluish. After heating in water until all the grains are gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* all color a moderate to deep indigo-blue and the *solution* a moderate indigo-blue. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the *grain-residues* all color a light to moderate indigo-blue, the *capsules* a reddish violet, and the *solution* a very deep indigo-blue.

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes they are light to moderately colored (value 38). The grains are all equally colored, and there is no variation in depth of color in different parts of an individual grain.

With *safranin* the grains all color very lightly at once, and in 30 minutes they are light to moderately colored (value 40), somewhat more than with gentian violet. The grains are all equally colored and there is no variation in depth of color in different parts of an individual grain.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 70° to 71.2° C., and of all is 74.5° to 76° C., mean 75.25° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 7 per cent of the total starch in 15 minutes; in about 8 per cent of the grains and 11 per cent of the total starch in 30 minutes; in about 14 per cent of the grains and 18 per cent of the total starch in 45 minutes; and in about 16 per cent of the grains and 20 per cent of the total starch in 60 minutes. (Chart D 335.)

The hilum becomes distinct, accompanied by the formation of a large bubble in only a few grains. The lamellæ are moderately distinct in the great majority of the grains, but in a few they are invisible. The grains become somewhat more refractive after the addition of the reagent, and the first portion of the grain to show this is a rather narrow portion just around the margin. Gelatinization begins at the distal margin and progresses according to two methods. In the first, which is seen in a majority of the grains which are also the more resistant, gelatinization begins at the distal margin and progresses smoothly toward the hilum and the proximal end. It progresses somewhat more rapidly along the margin than in the interior of the grain, so that the proximal end is gelatinized before the portion of the grain just distal to the hilum. Just before this last portion is gelatinized it is either split by a longitudinal fissure into two parts or is broken up into many small particles which are widely separated and gelatinize independently of one another. In the second method, which is seen in a minority of the grains which are also the less resistant, gelatinization begins at the distal end and then at the proximal end and progresses smoothly from these points, the portion just distal to the hilum being the last to be gelatinized. The gelatinized grains are much swollen, have rather thick capsules, and are greatly distorted.

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 15 per cent of the total starch in 15 minutes; in about 15 per cent of the grains and 65 per cent of the total starch in 30 minutes; in about 25 per cent of the grains and 80 per cent of the total starch in 45 minutes; and in about 35 per cent of the grains and 85 per cent of the total starch in 60 minutes. (Chart D 336.) (See footnote, page 516.)

The hilum becomes distinct, unattended by the formation of a bubble. The lamellæ are usually distinct, and evidence of a lamellar structure is visible during the greater part of the reaction. Gelatinization begins at the hilum and progresses according to two methods. In the first method, which is seen in a small majority of the grains, 2 furrows or actual fissures extend transversely or obliquely from either side of the hilum to the margin, and the material distal to them and to the hilum is divided into a great number of rather coarse granules by irregular fissures which criss-cross this portion of the grain in every conceivable direction. This granular mass now begins to gelatinize slowly, with considerable swelling, but not much distortion of the capsule. Meanwhile the starch at the proximal end is divided by very coarse striæ, and as the distal portion is gelatinized, the proximal deposit forms a coarsely striated and lamellated band at the proximal end which is slowly gelatinized long after the distal starch. In the second method, which is seen in a large minority of the grains, the primary material immediately surrounding the hilum is divided into many coarse refractive granules and the secondary starch is coarsely striated and furthermore divided by irregular fissures at the proximal and the distal ends. The less resistant starch is gelatinized more quickly at the portions which are fissured and the more resistant portion forms a striated and lamellated band at the margin which is thinner at the proximal and the distal ends of the grain. The granules of the primary starch are scattered around the inner border of this band and remain there, gradually growing smaller and more refractive for a long time after the material at the margin has been gelatinized, but finally disappear. The gelatinized grains are much swollen, have rather thin capsules, and are not much distorted. The grains are practically all gelatinized before they are dissolved.

The reaction with *pyrogallic acid* begins in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 0.5 per cent of the grains and 11 per cent of the total starch in 15 minutes; in about 11 per cent of the grains and 45 per cent of the total starch in 30 minutes; in about 26 per cent of the grains and 66 per cent of the total starch in 45 minutes; and in about 40 per cent of the grains and 77 per cent of the total starch in 60 minutes. (Charts D 337 and D 338.)

The hilum becomes distinct, unattended by the formation of a bubble in any of the grains. The lamellæ become moderately distinct, and evidence of a lamellar structure is visible in some parts of the grain during the greater part of the reaction. Gelatinization begins at the hilum and progresses according to two methods. In the first, which is seen in a small majority of the grains, 2 furrows, or in many cases fissures, extend transversely or obliquely from either side of the hilum to the margin, and the material distal to them and to the hilum loses its structural appearance and becomes a mass of fine granules which is sometimes divided by irregular longitudinal fissures. This granular starch slowly gelatinizes. In the meanwhile the proximal material is finely striated and as the distal portion swells it forms a finely striated, refractive band at the proximal margin which slowly grows thinner, but which in many grains is never completely gelatinized. In the second method, which is seen in a large minority of the grains, the primary starch immediately surrounding the hilum is divided into three or four portions, which, as the grain swells, are usually subdivided into many particles and widely scattered. The secondary which surrounds the primary material is covered by fine striæ and slowly gelatinizes, the more resistant portion forming a finely striated and lamellated band at the margin, around the inner border of which the particles of the primary starch are scattered. Gelatinization in many grains does not advance much further, but in some grains the primary starch granules disappear and the secondary marginal band slowly becomes thinner and more nearly transparent and is finally gelatinized. The gelatinized grains are much swollen, have rather thick capsules, and are considerably distorted.

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 10 per cent of the grains and 29 per cent of the total starch in 15 minutes; in about 13 per cent of the grains and 39 per cent of the total starch in 30 minutes; in about 19 per cent of the grains and 49 per cent of the total starch in 45 minutes; and in about 29 per cent of the grains and 56 per cent of the total starch in 60 minutes. (Chart D 339.)

The hilum becomes distinct, unattended by the formation of a bubble in any of the grains. The lamellæ are moderately distinct and evidence of a lamellar structure remains visible during the greater part of the reaction. Gelatinization begins at the hilum and progresses according to two methods. In the method which is seen in a small majority of the grains 2 furrows, or in some cases fissures, extend transversely or rarely obliquely from either side of the hilum to the margin and the material distal to them and to the hila loses its structural appearance and becomes a finely granular mass which is much cracked and fissured at the margin. The more resistant starch at the proximal end is coarsely striated, and as the grain swells with the gelatinization of the distal starch, it is pushed to the proximal margin, where it forms a granular band. These granules are gradually gelatinized, leaving only a rather thick capsule. In the second method, which is seen in a large majority of the grains, the primary starch immediately surrounding the hilum is divided by fissures into three or four portions, which, as the rest of the grain swells, are usually subdivided and scattered, but in a few grains remain clumped together in the center of the grain. The secondary deposit is divided by very distinct, coarse striæ into rows of granules according to the arrangement of the lamellæ. The less resistant material of the grain is now gelatinized, and the more resistant portion is pushed to the margin, where it forms a marginal band made up of 2 or 3 rows of granules, just inside the inner row of which are the scattered particles of the primary starch which are very resistant and often remain ungelatinized after the rest of the grain is gelatinized. The rows of granules constituting the marginal band are gelatinized from within outward, the outer row remaining visible for a long time. The gelatinized grains are much swollen, have rather thick capsules, and are considerably distorted.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 75 per cent of the entire number of grains and 93 per cent of the total starch in 2 minutes, and in about 97 per cent of the grains and 99 per cent of the total starch in 5 minutes. (Chart D 340.)

The hilum becomes distinct, accompanied by the formation of a bubble in a large majority of the grains. The lamellæ at first are not distinct, but later become distinct and are then quickly obscured. Gelatinization begins in the interior of the grain and proceeds according to two methods. In the first method, which is seen in a rather small majority of the grains, 2 furrows or actual fissures extend transversely or obliquely from the hilum on either side to the margin, and the material distal to these furrows and to the hilum becomes distinctly refractive, then the lamellæ are separated from one another by refractive fissures, and the whole mass of starch is rapidly gelatinized with much swelling and considerable distortion of the capsule. The proximal portion meanwhile remains unaffected, and as the distal material swells it forms a thick, homogeneous-looking band at the proximal margin, which is later comparatively slowly gelatinized. In the second method, which is seen in a large minority of the grains, the material immediately surrounding the hilum, which is a primary starch formation, becomes granular in appearance and is broken up into three or four portions by the swelling of the bubbles at the hilum; meanwhile the lamellæ of the secondary starch surrounding the primary deposit are separated from one another by concentric, refractive fissures. Following this the whole grain is rapidly gelatinized, the secondary starch swelling with great rapidity and the granular portions of the primary starch being widely separated and gelatinizing less rapidly. The gelatinized grains are much swollen, have rather thin capsules, and are much distorted.

Narcissus triandrus albus (Pollen Parent).

(Plates 14 and 15, figs. 83 and 86; Charts D 335 to D 340.)

Histologic Properties.

In *form* a small majority of the grains are simple and most of the grains are isolated. A large minority are compound and there are a few aggregates. The compound grains belong to the following two types: (1) From 2 to 7 rather small grains, each consisting of a hilum surrounded by 2 or 3 lamellæ and all inclosed in 6

or 7 common secondary lamellæ; (2) 4 to 7 or 8 hila in an amorphous-looking mass of starch which is surrounded by 1 or 2 secondary lamellæ. There are more compound grains and fewer aggregates than in *N. leedsii minnie hume.* The aggregates are of 2 or 3 small grains arranged linearly. There are a few grains in which a primary and a secondary starch formation may be seen, somewhat fewer than in *N. leedsii minnie hume.* The grains are not so irregular as in *N. leedsii minnie hume* and the irregularities which occur are due to the following causes, which are the same as those in *N. leedsii minnie hume:* (1) Small or large rounded or pointed protuberances from the sides or ends; (2) small irregular elevations and depressions of the surfaces or margins of the grains; (3) a greater development of one part of the distal end or of one side; (4) a deviation of the long axis at either end, with a consequent bending of the grain. The conspicuous forms are ovoid, which may be broad or narrow, and lenticular. The additional forms are broad elliptical, reniform, irregularly quadrilateral with rounded corners, triangular, round, nearly round, and dome-shaped. As in *N. leedsii minnie hume* some of the larger grains are flattened, but most of the grains are not flattened.

The *hilum,* when not fissured, is a rather indistinct small, round, or lenticular-shaped spot. It is more often and more deeply and extensively fissured than in *N. leedsii minnie hume.* The fissures have the following forms, which are the same as those seen in *N. leedsii minnie hume:* (1) V-, Y-, or cruciate-shaped; (2) a single straight or curved transverse or oblique line; (3) a flying-bird figure; (4) an irregularly stellate collection of fissures. The hilum is sometimes centric, but in the majority of the grains it is eccentric from 0.45 to 0.18, usually 0.33, of the longitudinal axis.

The *lamellæ* are usually not visible, and when they can be seen appear as rather fine continuous rings which, when near the hilum, often do not conform to the outline of the grain, but which follow this closely when near the margin. The lamellæ are not so often distinct nor so fine as in *N. leedsii minnie hume.* The whole number on the grains can not be counted.

In *size* the grains vary from the smaller which are 2 by 2μ, to the larger broad forms which are 40 by 40μ, and the elongated forms which are 40 by 30μ, in length and breadth. The common sizes are 24 by 20μ and 24 by 24μ. The grains, as a whole, are smaller than in *N. leedsii minnie hume.*

Polariscopic Properties.

The *figure* is usually distinct and is somewhat better defined than in *N. leedsii minnie hume.* The lines cross at a right angle or at an acute angle which does not vary any more in size than in *N. leedsii minnie hume.* They are not so often bent or bisected as in *N. leedsii minnie hume,* nor are there so often 5 or 6 lines instead of 4. The figure is not so often in the form of a conjugate hyperbola, or of a long line with bisected ends.

The *degree of polarization* varies from low to high (value 50), more than in *N. leedsii minnie hume,* as there are a few more grains in which it is moderately high, and higher than in that starch. There is also less variation in a given aspect of an individual grain.

With *selenite* the quadrants are more often clear-cut, and are more regular in shape, but just as unequal in size as in *N. leedsii minnie hume.* The colors are usually not pure, but more often pure, and there are more grains which have a greenish tinge than in *N. leedsii minnie hume.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a deep violet tinged with blue (value 65), more than in *N. leedsii minnie hume,* and with more of a bluish tint. The color deepens with great rapidity until very deep and more bluish. With 0.125 per cent Lugol's solution the grains color a light to moderate violet tinged with blue, more than in *N. leedsii minnie hume,* and with more of a bluish tint. The color deepens rapidly until very deep and more bluish. If the grains are heated in water until they are all gelatinized and then treated with a 2 per cent Lugol's solution, the gelatinized *grains* all color a moderate indigo-blue, less than in *N. leedsii minnie hume;* and the *solution* a deep indigo-blue, more than in *N. leedsii minnie hume.* If the preparation is boiled for 2 minutes and then treated with a 2 per cent Lugol's solution, the *grain-residues* all color a light indigo-blue, less than in *N. leedsii minnie hume;* the *capsules* red or reddish violet, more reddish than in *N. leedsii minnie hume;* and the *solution* a very deep indigo-blue, the same as in *N. leedsii minnie hume.*

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes they are light to moderately colored (value 35), somewhat less than in *N. leedsii minnie hume.* The grains are all equally colored and there is no variation in color in different parts of the individual grains.

With *safranin* the grains all color very lightly at once, and in 30 minutes they are light to moderately colored (value 40), the same as in *N. leedsii minnie hume.* The grains are all equally colored and there is no variation in color in different parts of the individual grains.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 70° to 71° C., and of all is 73° to 75° C., mean 74° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the grains and total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 7 per cent of the total starch in 30 minutes; in about 9 per cent of the grains and 11 per cent of the total starch in 45 minutes; and in little if any further advance in 60 minutes. (Chart D 335.)

The hilum becomes distinct, accompanied by the formation of a bubble in many more grains than in *N. leedsii minnie hume.* The lamellæ are not visible in any of the grains. The grains are more refractive than in *N. leedsii minnie hume* and the first portion to show this is a rather narrow part of the margin. Gelatinization begins at the distal margin and progresses in general according to the two methods described under *N. leedsii minnie hume.* In the first, which is seen in a smaller

majority of the resistant grains than in *N. leedsii minnie hume,* gelatinization begins at the distal margin and progresses smoothly toward the hilum and proximal end. It does not progress more rapidly around the margin than in the interior of the grains as in *N. leedsii minnie hume,* and the proximal end is the last part of the grain to be gelatinized instead of the portion just distal to the hilum as in *N. leedsii minnie hume.* In the second method gelatinization begins at the distal end and progresses from there smoothly up to the proximal end, or at the distal end and then at the proximal end, as in *N. leedsii minnie hume,* and progresses smoothly from these two points, the material just distal to the hilum being the last to be gelatinized.

The gelatinized grains are very much swollen and have rather thin capsules. They are even more distorted than in *N. leedsii minnie hume.*

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about the same percentage of the grains and 20 per cent of the total starch in 15 minutes; in about 10 per cent of the grains and 70 per cent of the total starch in 30 minutes; in about 43 per cent of the grains and 94 per cent of the total starch in 45 minutes; and in about 53 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 336.) (See footnote, page 516.)

The hilum and lamellæ are as distinct as in *N. leedsii minnie hume,* and evidence of a lamellar structure persists as long as in the grains of that starch. Gelatinization begins at the hilum and progresses according to two methods, which are similar to the two described under *N. leedsii minnie hume.* In the first, which is seen in a majority of the grains and which is similar to that described for a large minority of those of *N. leedsii minnie hume,* the primary starch around the hilum is divided into very fine granules which are much finer and less distinct than those in *N. leedsii minnie hume,* and a sheaf of irregular fissures extends through the secondary starch to the distal and proximal margins of the grain. The remainder of the secondary starch is divided by very coarse striæ. The less resistant portion of the secondary starch gelatinizes and the grain swells. The more resistant starch forms a band at the margin which is coarsely striated and lamellated and which is not continuous, as the deposit at the proximal and the distal ends is gelatinized quickly. The interior of the grain is finely granular, and these granules are gelatinized before the marginal band, which slowly grows thinner and more nearly transparent, retaining the lamellar appearance until all the material is gelatinized. In the second method, which is similar to that seen in a small majority of the grains of *N. leedsii minnie hume,* 2 furrows or fissures extend transversely or obliquely from either side of the hilum to the margin and the material which is distal to them and to the hilum is divided into a mass of rather fine refractive granules by many irregular fissures and rather slowly gelatinizes with much swelling but not much distortion of the capsule. The proximal starch is divided by rather coarse striæ, and as the grain swells forms a coarsely striated and lamellated band at the proximal margin, which is even more slowly gelatinized than the distal material. The grains as in *N. leedsii minnie hume* are all gelatinized before they are dissolved. The gelatinized grains are much swollen, have as thin capsules, and are no more distorted than in *N. leedsii minnie hume.*

The reaction with *pyrogallic acid* begins in 30 seconds. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 21 per cent of the total starch in 15 minutes; in about 41 per cent of the grains and 78 per cent of the total starch in 30 minutes; in about 56 per cent of the grains and 85 per cent of the total starch in 45 minutes; and in about 67 per cent of the grains and 91 per cent of the total starch in 60 minutes. (Chart D 337.)

The hilum becomes as distinct as in *N. leedsii minnie hume,* unattended by the formation of a bubble. The lamellæ are moderately distinct, and evidence of a lamellar structure is as distinct as in *N. leedsii minnie hume.* Gelatinization begins at the hilum and follows three methods of procedure. In the first, which is seen in a large number of grains, which is not, however, a majority of the whole number, 2 furrows or actual fissures extend transversely or slightly obliquely from the hilum on either side to the margin and the material distal to them and to the hilum becomes a finely granular mass as in *N. leedsii minnie hume.* This portion slowly gelatinizes, with some swelling of the grain, and the proximal deposit is first covered by very fine and often rather indistinct striæ, but as the grain swells forms a homogeneous-looking, refractive band at the proximal margin, which is gelatinized even more slowly than the distal material, in many grains not reaching complete gelatinization. The second and third methods are seen in equal numbers of the remaining grains. In the second method the hilum enlarges somewhat and the grain is covered by fine striæ and gelatinizes slowly, the more resistant starch forming a finely striated band at the margin, which very slowly becomes thinner and more nearly transparent until it is completely gelatinized. In the third method the primary starch around the margin is divided into a number of coarse granules which are scattered as the grain swells. The secondary deposit is covered with fine striæ and the less resistant portion is gelatinized, while the more resistant portion forms a finely striated and lamellated marginal band, around which are scattered the granules of the primary starch and which slowly becomes thinner and more nearly transparent, but in some grains is not completely gelatinized. The gelatinized grains are as much swollen, have as thick capsules, and are as much distorted as in *N. leedsii minnie hume.*

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 7 per cent of the grains and 32 per cent of the total starch in 15 minutes; in about 23 per cent of the grains and 46 per cent of the total starch in 30 minutes; in about 31 per cent of the grains and 59 per cent of the total starch in 45 minutes; and in about 35 per cent of the grains and 62 per cent of the total starch in 60 minutes. (Chart D 339.)

The hilum is as distinct as in *N. leedsii minnie hume* and the lamellæ are moderately distinct, but not so distinct as in *N. leedsii minnie hume,* but evidence of a

lamellar structure is just as persistent as in the grains of that starch. Gelatinization begins at the hilum and follows three methods of procedure instead of two as in *N. leedsii minnie hume.* In the method noted in a number of the grains, 2 furrows or fissures extend transversely or slightly obliquely from the hilum on either side to the margin, and the material included between them and the hilum and the margin is divided irregularly into fine granules, which are, however, less fine and more definite than those found in the grains of *N. leedsii minnie hume* which follow this method of gelatinization. After the division into granules the starch is criss-crossed by irregular fissures and begins to gelatinize from the hilum outward, with much irregular swelling and considerable distortion of the capsule. In the meantime the more resistant portion at the proximal end and sides nearby is divided by coarse striæ, which are, however, not so coarse as those noted in similar grains of *N. leedsii minnie hume,* and pushed to the proximal margin, where it remains as the rest of the grain is gelatinized, gradually growing thinner and more nearly transparent. There is no formation of granules from this material at the margin as in *N. leedsii minnie hume,* but as it becomes more and more gelatinous it assumes a more and more homogeneous appearance. In the method noted in a number of the remaining grains, the hilum enlarges somewhat, and the grain is divided by rather coarse striæ radiating from the hilum to the margin, and as the less resistant starch is gelatinized the more resistant starch is pushed to the margin, where it forms a coarsely striated and moderately distinctly lamellated band, which gradually grows progressively thinner and more nearly transparent, at the same time losing the striated appearance but retaining the lamellated appearance for a long time. This method is not seen in *N. leedsii minnie hume.* The third method occurs in about the same number of grains as the second method, and resembles that seen in a large minority of the grains of *N. leedsii minnie hume.* The starch immediately around the hilum, which probably represents a primary formation, is divided into several pieces, which are subdivided and scattered as the grain swells. The starch around the primary starch, which probably represents a secondary formation, becomes striated, and as the less resistant material is gelatinized the more resistant portion is pushed to the margin, where it forms a coarsely striated, rather indistinctly lamellated band which is not divided into granules as in *N leedsii minnie hume,* and around the inner border of which are arranged the particles, the primary starch. These are very resistant and remain, slowly becoming smaller and more refractive, after the rest of the grain is completely gelatinized. The marginal band meanwhile grows progressively thinner, more homogeneous-looking, and more nearly transparent, until all the starch is gelatinized and only a rather thick capsule is left. The gelatinized grains are as much swollen, have as thick capsules, and are as much distorted as those of *N. leedsii minnie hume.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 65 per cent of the entire number of grains and 83 per cent of the total starch in 2 minutes; in about 91 per cent of the grains and 97 per cent of the total starch in 5 minutes; and in about 95 per cent of the grains and in more than 99 per cent of the total starch in 10 minutes. (Chart D 340.)

The hilum becomes distinct, accompanied by the formation of a large bubble in a large majority of the grains, as in *N. leedsii minnie hume.* The lamellæ are never distinct, as they are in *N. leedsii minnie hume.* Gelatinization begins in the interior of the grain and proceeds in general according to the two methods described under *N. leedsii minnie hume.* In the first method, which is noted in a majority of the grains and which is the same as that seen in a large minority of the grains of *N. leedsii minnie hume,* the material immediately surrounding the hilum, and which represents a primary starch formation, becomes granular, and as the bubble at the hilum swells is divided into three or four portions of varying size. The deposit which surrounds this primary grain and which represents a secondary starch formation becomes homogeneous in appearance, in this differing from *N. leedsii minnie hume,* and swells very rapidly, with considerable distortion of the capsule; the portions of the primary starch are widely separated and are gelatinized somewhat more slowly. In the second method, which is noted in a minority of the grains and which is nearly the same as that seen in a small majority of the grains of *N. leedsii minnie hume,* 2 furrows or actual fissures extend transversely or obliquely from either side of the hilum to the margin and the material distal to these furrows and to the hilum becomes homogeneous-looking and more refractive in certain circumscribed areas, in this differing from *N. leedsii minnie hume,* and gelatinizes rapidly, with much swelling and considerable distortion of capsule. The proximal material meanwhile is not affected, and as the distal portion swells it forms a thick, homogeneous-looking band at the proximal margin which is later, comparatively slowly, gelatinized. The gelatinized grains are as much swollen, have as thin capsules, and are as much distorted as in *N. leedsii minnie hume.*

Narcissus agnes harvey (Hybrid).

(Plate 14, fig 84; Charts D 335 to D 340.)

Histologic Properties.

In *form* the grains are usually simple and isolated, and there are not so many compound grains or aggregates as in either parent, in this respect more nearly resembling *N. leedsii minnie hume* than *N. triandrus albus.* The compound grains belong to the same types as have been described under *N. triandrus albus.* The grains are more irregular than in *N. triandrus albus* and as irregular as in *N. leedsii minnie hume,* and the irregularities are due to the same causes as in both parents. There are, as in *N. triandrus albus,* very few grains in which a primary and a secondary starch formation can be clearly seen. The conspicuous forms are ovoid, triangular with or without a curved base, and lenticular. The additional forms are irregularly quadrilateral and polygonal, reniform, pyriform, and elliptical. In form *N. agnes harvey* shows a somewhat closer relationship to *N. leedsii minnie hume* than to *N. triandrus albus.*

The *hilum,* when not fissured, is as distinct as in *N. leedsii minnie hume.* It is not fissured so often nor so deeply and extensively as in either parent, and in this respect more closely resembles *N. leedsii minnie hume*

than *N. triandrus albus.* The fissures have the following forms: (1) **T, Y,** and cruciate figures; (2) a single straight, transverse, oblique, or longitudinal line; (3) an irregularly stellate collection of fissures. The hilum is sometimes centric, but in the majority of the grains it is eccentric from 0.44 to 0.2, usually 0.33, of the longitudinal axis.

In the character of the hilum *N. agnes harvey* shows a closer relationship to *N. leedsii minnie hume* than to *N. triandrus albus.* The eccentricity of the hilum in the three starches is so nearly the same that there is no differentiation.

The *lamellæ* are as often distinct as in *N. leedsii minnie hume,* and more distinct than in *N. triandrus albus.* They are as fine as in *N. leedsii minnie hume* and have the same arrangement as in that starch. The number counted on some of the larger grains varies from 6 to 16, usually 12. In the character of the lamellæ *N. agnes harvey* shows a closer relationship to *N. leedsii hume* than to *N. triandrus albus.*

In *size* the grains vary from the smaller which are 3 by 3μ, to the larger broad forms which are 40 by 40μ and 36 by 40μ, and the larger elongated forms which are 40 by 34μ, in length and breadth. The common sizes are 22 by 18μ, 24 by 24μ, and 22 by 24μ in length and breadth. In size the grains of *N. agnes harvey* shows a closer relationship to *N. triandrus albus* than to *N. leedsii minnie hume.*

Polariscopic Properties.

The *figure* as in *N. leedsii minnie hume* is usually moderately distinct and well defined. The lines cross at an acute angle which does not vary greatly in size in the different grains, and are frequently bent and sometimes bisected, more often than in *N. triandrus albus* but as often as in *N. leedsii minnie hume.* There are as often 5 or 6 lines instead of 4, and the figure as often has the form of a conjugate hyperbola, or a long line bisected at both ends, as in *N. leedsii minnie hume.*

The *degree of polarization* varies from low to high (value 45), the same as in *N. leedsii minnie hume.* There is the same amount of variation in a given aspect of an individual grain as in that starch.

With *selenite* the quadrants, as in *N. leedsii minnie hume,* are moderately clear-cut, unequal in size, and often irregular in shape. The colors are as often impure and as often have a greenish tinge as in that starch.

In the degree of polarization, the character of the figure, and the appearances with selenite, *N. agnes harvey* shows a closer relationship to *N. leedsii minnie hume* than to *N. triandrus albus.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate to deep violet tinged with blue (value 60), the same as in *N. leedsii minnie hume.* With 0.125 per cent Lugol's solution, they all color a light to moderate violet, the same as in *N. leedsii minnie hume.* After heating in water until the grains are all gelatinized, and then treating with a 2 per cent Lugol's solution, the gelatinized *grains,* as in *N. leedsii minnie hume,* all color a moderate to moderately deep indigo-blue, and the *solution* a moderate indigo-blue. If the preparation is boiled for 2 minutes and then treated with a 2 per cent Lugol's solution, the *grain-residues,* as in *N. leedsii minnie hume,* all color a light to moderate or moderate indigo-blue, the *capsules* a reddish violet, and the *solution* an indigo-blue. Qualitatively and quantitatively the reaction with iodine shows a closer relationship to *N. leedsii minnie hume* than to *N. triandrus albus.*

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes they are light to moderately colored (value 38), the same as in *N. leedsii minnie hume.*

With *safranin* the grains all color very lightly at once, and in 30 minutes they are light to moderately colored (value 40), the same as in both parents.

In the reactions with aniline stains *N. agnes harvey* shows a somewhat closer relationship to *N. leedsii minnie hume* than to *N. triandrus albus.* There are, however, no marked differences between either of the parents or the hybrid in these reactions.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 70° to 71.8° C., and of all is 73.8° to 75° C., mean 74.4° C.

The temperature of gelatinization of *N. agnes harvey* is somewhat closer to that of *N. triandrus albus* than *N. leedsii minnie hume,* though the temperatures of gelatinization of the three starches are very close to one another.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 1 minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 7 per cent of the total starch in 15 minutes; in about 6 per cent of the grains and 8 per cent of the total starch in 30 minutes; in about 8 per cent of the grains and 12 per cent of the total starch in 45 minutes; and in about 9 per cent of the grains and 14 per cent of the total starch in 60 minutes. (Chart D 335.)

The hilum becomes distinct, accompanied by the formation of a bubble in as few grains as in *N. leedsii minnie hume.* The lamellæ are moderately distinct in a smaller number of grains than in *N. leedsii minnie hume,* and are not visible in the others as in all the grains of *N. triandrus albus.* After the addition of the reagent the grains become as refractive as in *N. triandrus albus* and more refractive than in *N. leedsii minnie hume.* Gelatinization begins at the distal margin and progresses according to the two methods described under both parents. In the first, which is seen in a larger majority of the grains than in *N. leedsii minnie hume* and a much larger majority than in *N. triandrus albus,* it progresses according to the method described under *N. leedsii minnie hume,* except that there is considerable fissuring and breaking off of particles from the ungelatinized material. This is not seen in either parent. In the second method, which is noted in rather few of the grains, gelatinization progresses from both ends as in both parents, or from the distal end only as in *N. triandrus albus.* The gelatinized grains are as much swollen, have as thick capsules, and are as much distorted as in *N. leedsii minnie hume.*

In this reaction *N. agnes harvey* shows qualitatively a closer relationship to *N. leedsii minnie hume* than to *N. triandrus albus.*

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the grains and 4 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 17 per cent of the total starch in 15 minutes; in about 9 per cent of the grains and 42 per cent of the total starch in 30 minutes; in about 14 per cent of the grains and 72 per cent of the total starch in 45 minutes; and in about 23 per cent of the grains and 82 per cent of the total starch in 60 minutes. (Chart D 336.) (See footnote, page 516.)

The hilum and lamellæ are as distinct as in both parents. Gelatinization begins at the hilum and progresses according to the two methods described under both parents. The first method, which is seen in a small majority of the grains, is the same as that described for a small majority of the grains of *N. leedsii minnie hume.* In a large minority the method is very nearly the same as that described for a large minority of the grains of *N. leedsii minnie hume,* the differences being that the particles of the primary starch are more apt to remain clumped together in the center of the grain while the rest of the grain is gelatinized, and are more resistant than in *N. leedsii minnie hume.* The grains, as in both parents, are not dissolved until they have been completely gelatinized. The gelatinized grains are as much swollen, have as thick capsules, and are no more distorted, than in both parents. In this reaction *N. agnes harvey* shows qualitatively a closer relationship to *N. leedsii minnie hume* than to *N. triandrus albus.*

The reaction with *pyrogallic acid* begins in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 30 minutes; in about 45 per cent of the grains and 20 per cent of the total starch in 15 minutes; in about 33 per cent of the grains and 63 per cent of the total starch in 30 minutes; in about 45 per cent of the grains and 75 per cent of the total starch in 45 minutes; and in about 57 per cent of the grains and 81 per cent of the total starch in 60 minutes. (Chart D 337.)

The hilum and lamellæ are as distinct as in both parents. Gelatinization begins at the hilum and progresses according to two methods as in *N. leedsii minnie hume,* instead of three as in *N. triandrus albus.* In a small majority the method is the same as that in a similar number of the grains of *N. leedsii minnie hume.* In a large minority the method is nearly the same as that in a similar number of grains of *N. leedsii minnie hume.* The differences are that the particles of the primary starch more often remain clumped together and ungelatinized instead of being scattered as the grain swells, and the striæ which are seen in the secondary starch are finer and less distinct. The gelatinized grains are as much swollen, have as thick capsules, and are as much distorted as in both parents. In this reaction *N. agnes harvey* shows qualitatively a closer relationship to *N. leedsii minnie hume* than to *N. triandrus albus.*

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 15 per cent of the grains and 55 per cent of the total starch in 15 minutes; in about 25 per cent of the grains and 65 per cent of the total starch in 30 minutes; in about 30 per cent of the grains and 70 per cent of the total starch in 45 minutes; and in about 35 per cent of the grains and 73 per cent of the total starch in 60 minutes. (Chart D 339.)

The hilum and lamellæ are distinct as in *N. leedsii minnie hume.* Gelatinization begins at the hilum and follows two methods of procedure, as in *N. leedsii minnie hume,* instead of three, as in *N. triandrus albus.* In a small majority the method is the same as that in a similar number of grains of *N. leedsii minnie hume,* and in a large minority the method is nearly the same as in a corresponding number of grains of *N. leedsii minnie hume,* the differences noted being that the striæ which divide the secondary starch are not so coarse and the particles of the primary starch more often remain clumped together in the center of the grain instead of being scattered. The gelatinized grains are as much swollen, have as thick capsules, and are as distorted, as in both parents. In this reaction *N. agnes harvey* shows qualitatively a much closer relationship to *N. leedsii minnie hume* than to *N. triandrus albus.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 83 per cent of the entire number of grains and 95 per cent of the total starch in 2 minutes; and in about 96 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 340.)

The hilum, as in both parents, becomes distinct, with the formation of a bubble in a large majority of the grains. Gelatinization begins in the interior of the grains and follows two methods of procedure, which are the same as those described in *N. leedsii minnie hume.* There is no marked difference between the hybrid and the parents in this reaction. The gelatinized grains are as much swollen, have as thin capsules, and are as much distorted as in both parents. In this reaction *N. agnes harvey* shows qualitatively a somewhat closer relationship to *N. leedsii minnie hume* than to *N. triandrus albus.*

24. Starches of Narcissus emperor, N. triandrus albus, and N. J. T. Bennett Poe.

Starch of *N. triandrus albus* is described on pages 586 to 589.

Narcissus emperor (Seed Parent).

(Plate 15, fig. 85; Charts D 341 to D 346.)

Histologic Properties.

In *form* the grains are usually simple and isolated, but there is a moderate number of both compound grains and aggregates. The compound grains belong to the following two types: (1) 2 to 4 small grains (each consisting of a hilum and 2 or 3 lamellæ) having become adherent and surrounded by 6 or 7 secondary lamellæ; (2) 6 to 8 or 9 hila in an amorphous-looking mass of starch which is surrounded by 1 or 2 secondary lamellæ. The aggregates consist of 2 to 4 small or moderate-sized grains linearly or compactly arranged, and there are also aggregates consisting of a compound grain and a simple grain, and of 2 compound grains. There is a majority of the simple grains which show a small or moderate-sized primary grain around which has been deposited several secondary lamellæ. The grains are often irregular and the irregularities are due to the following causes:

(1) Large or small pointed or rounded protuberances from the sides or either end; (2) small, irregular depressions and elevations of the surface and margin; (3) a greater development of one part of the distal end or of one side than the rest; (4) irregular and poorly defined pressure facets; (5) a deviation of the long axis at either end, with a consequent bending of the grain. The conspicuous forms are ovoid, lenticular, nearly round, dome-shaped, plano-convex, and elliptical. There are also clam-shell-shaped, round, reniform, pyriform, irregularly quadrilateral, and triangular with rounded angles. The broader forms are somewhat flattened, the others are not.

The *hilum*, when it is not fissured, is a rather indistinct, small, round, or lenticular spot. It is usually fissured, but not deeply nor extensively, and the fissures have the following forms: (1) Y- or T-shaped; (2) a single short, straight or curved line lying transversely, obliquely, or longitudinally; (3) an irregularly stellate arrangement of several fissures; (4) a flying-bird form. The hilum is often centric, but in the majority of the grains it is eccentric from 0.44 to 0.31, usually 0.4, of the longitudinal axis.

The *lamellæ* are usually not visible, but in a few grains they are moderately distinct and appear as rather fine continuous rings which have in general the form of the outline of the grain. They are more distinct near the hilum than the margin, except in those grains which have both primary and secondary starch, and in such grains, when they can be seen at all, they can only be found in the secondary starch. The total number can not be determined on any grain.

In *size* the grains vary from the smaller which are 3 by 3μ, to the larger elongated forms which are 36 by 28μ, and the larger broad forms which are 30 by 40μ, rarely, 30 by 50μ, in length and breadth. The common sizes are 28 by 20μ and 24 by 30μ.

Comparison of the *histologic properties* between *N. triandrus albus* and *N. emperor* shows:

There are more compound grains and a few more aggregates than in *N. emperor* and the compound grains belong to the same two types that were described under *N. emperor,* the only exception being that these grains may have more components. No aggregates of compound grains and simple grains, or of compound grains only, are seen. There are not so many simple grains which show a primary and a secondary starch formation. The grains are more irregular than in *N. emperor,* and the irregularities are due to the same causes, except that pressure facets are not seen on these grains. The grains are not so varied in form as in *N. emperor.*

The *hilum* when not fissured is no more distinct than in *N. emperor,* but it is more often and somewhat more deeply and extensively fissured than in that starch. The fissures have the same forms, except that a cruciate figure is frequently seen. The hilum is more eccentric, the usual degree of eccentricity being 0.33 of the longitudinal axis.

The *lamellæ* are somewhat more often visible and when so are somewhat more distinct. They are not quite so fine, and when near the hilum do not follow the form of the outline of the grain, but otherwise they resemble those of *N. emperor.*

In *size* the grains are not quite so large as those of *N. emperor,* though the differences are slight.

Polariscopic Properties.

The *figure* is usually distinct, but is commonly not very well defined. The lines generally cross at right angles, but sometimes cross at acute angles which do not vary greatly in size in the different grains. They are, as a rule, not bent, and rarely are bisected. The figure, rarely, has the form of a conjugate hyperbola, or of a long line bisected at both ends.

The *degree of polarization* varies from low to high (value 60). Most of the grains have a moderate or moderate to high degree of polarization. There is some variation in a given aspect of some of the individual grains.

With *selenite* the quadrants are usually not clear-cut, and are unequal in size, and usually regular in shape. The colors are often pure but sometimes not pure, the yellow more often than the blue. In some of the grains there is a greenish tinge.

Comparison of the *polariscopic properties* between *N. triandrus albus* and *N. emperor* shows:

The *figure* is not so distinct, but is more often well defined. The lines are less apt to cross at right angles, and more apt to cross at acute angles which do not vary much. They are, as in *N. emperor,* not often bent or bisected, and there are the same number of grains in which the figure has the form of a conjugate hyperbola, or a long line bisected at both ends.

The *degree of polarization* is lower than in *N. emperor* (value 50), as there are fewer grains in which it is moderate to high and high.

With *selenite* the quadrants are more often clear-cut, and are of the same regularity. The colors are less often pure and there are fewer grains which have a greenish tinge.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate to deep violet tinged with blue (value 60), and the color deepens rapidly until very deep and has assumed more of a bluish tint. With 0.125 per cent Lugol's solution the grains all color a light to moderate violet, and the color deepens rapidly until it is very deep, and has assumed a bluish tint. After heating in water until all the grains are gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* color a moderate indigo and the *solution* a deep indigo. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the *grain-residues* all color a light indigo, the *capsules* a red or a reddish violet, and the *solution* a very deep indigo-blue.

Comparison of the *iodine reactions* between *N. triandrus albus* and *N. emperor* shows:

With 0.25 per cent Lugol's solution the grains all color more than those of *N. emperor* (value 65); so also with 0.125 per cent Lugol's solution. After heating in water until the grains are all gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized grains and the solution color the same as in *N. emperor.* If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the grain-residues, the capsules, and the solution all color the same as in *N. emperor.*

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes they are moderately colored (value 45). The grains are all equally colored, and there is no variation in the depth of color in different parts of an individual grain.

With *safranin* the grains all color, very lightly at once, and in 30 minutes they are moderately colored (value 50), more than with gentian violet. The grains are all equally colored and there is no variation in depth of color in different parts of an individual grain.

Comparison of the *aniline reactions* between *N. triandrus albus* and *N. emperor* shows:

With gentian violet the grains color light to moderately (value 35), much less than in *N. emperor.*

With safranin they color light to moderately (value 40), much less than in *N. emperor.*

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 69° to 71° C., and of all is 74° to 75.5° C., the mean is 74.53° C.

Comparison of the *temperature reactions* between *N. triandrus albus* and *N. emperor* shows:

The temperature of gelatinization is somewhat less, 73° to 75° C., mean 74° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in rare grains in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 6 per cent of the total starch in 15 minutes; in about 13 per cent of the grains and 18 per cent of the total starch in 30 minutes; in about 15 per cent of the grains and 23 per cent of the total starch in 45 minutes; and in about 23 per cent of the grains and 28 per cent of the total starch in 60 minutes. (Chart D 341.)

The hilum becomes distinct, accompanied by the formation of a large bubble in a moderate number of grains. The lamellæ are, at first, not visible, but later become distinct in all the grains. The grains become more refractive in appearance after the addition of the reagent, and the first part of the grain to show this change is a rather narrow band of starch at the margin. Gelatinization begins at either the distal or the proximal end and progresses according to two methods. In the first, which is seen in the majority of the grains, which are also the more resistant grains, gelatinization begins at various points on the distal margin, then the marginal starch is partially separated from the rest by a refractive fissure which extends on either side to the proximal end, and is gelatinized. Following this the proximal end is gelatinized and the hilum swells, and if a bubble is present it swells, then shrinks and disappears, and a longitudinal fissure extends distally through the ungelatinized starch, splitting it into two pieces which are gelatinized independently of one another. In the second method gelatinization begins at the distal end only and progresses toward the hilum and proximal end, preceded by some fissuring and splitting off of particles from the ungelatinized material, or it begins at the distal end and then at the proximal end and progresses from these two points, the portion just distal to the hilum being the last to be gelatinized. The gelatinized grains are considerably swollen, have thin capsules, and are much distorted.

Comparison of the *chloral-hydrate* reaction between *N. triandrus albus* and *N. emperor* shows:

The hilum becomes distinct, accompanied by the formation of a bubble much more frequently than in *N. emperor.* The lamellæ are never visible. The grains become as refractive as in *N. emperor* after the reagent is added, the first part to be affected being the margin. Gelatinization begins at the distal margin, and progresses in general according to the two methods described in *N. emperor.* In the first, which is seen in the same number of grains as in *N. emperor,* the main differences to be noted are that there is no preliminary serial separation of the lamellæ and that the margin is not gelatinized much more rapidly than the rest of the grain, so that the proximal end is the last part of the grain to be gelatinized instead of the portion just distal to the hilum, which is not split into two pieces as in *N. emperor.* In the second method the main differences noted are that gelatinization always begins first at the distal end, instead of sometimes at the proximal and then at the distal end, and the progress is somewhat smoother than in *N. emperor.* The gelatinized grains are considerably swollen, the capsules are somewhat less thin, and they are not so much distorted as in *N. emperor.*

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 24 per cent of the grains and 39 per cent of the total starch in 15 minutes; in about 36 per cent of the grains and 75 per cent of the total starch in 30 minutes; in about 42 per cent of the grains and 94 per cent of the total starch in 45 minutes; and in about 57 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 342.) (See footnote, page 516.)

The hilum becomes distinct, unattended by the formation of a bubble. The lamellæ are distinct, and evidence of a lamellar structure persists throughout the greater part of the reaction. Gelatinization begins at the hilum and progresses according to but one method in all but rare grains. Two furrows or fissures extend horizontally from either side of the hilum to the margin, and the primary deposit which is around the hilum is cracked and broken into several portions which later are subdivided into coarse granules. The secondary starch distal to the 2 furrows, except a narrow band of material at the margin, is divided by coarse striæ and then by several irregular branching fissures and gelatinizes slowly with considerable swelling of the grain. The starch proximal to the 2 fissures is coarsely striated, and as the grain swells it, in conjunction with the narrow band of starch around the distal margin, forms a continuous, coarsely striated, and lamellated marginal band which is thicker and less refractive and more resistant at the proximal end. The granules of the primary starch are scattered around the inner border of this band, and often remain after the rest of the grain is gelatinized, but usually are themselves gelatinized later. In some grains the capsule at the distal end is dissolved before gelatinization is complete and the contents flow out and are dissolved. In most of the grains, however, the starch

at the margin grows slowly thinner and more nearly transparent and is finally gelatinized, that at the proximal being the last. A few of the grains are dissolved before gelatinization is complete. The gelatinized grains are much swollen, have rather thin capsules, and are not much distorted.

Comparison of the *chromic-acid* reactions between *N. triandrus albus* and *N. emperor* shows:

The hilum and lamellæ are not quite so distinct as in *N. emperor*. Gelatinization progresses according to two methods instead of but one as in *N. emperor*. In the first, which is seen in a majority of the grains and which is in some respects similar to that seen in *N. emperor*, the primary starch around the hilum is broken up into very fine granules and a sheaf of irregular fissures extends to the proximal and to the distal margins. From this point the reaction is the same as in *N. emperor*, except that the marginal band is more rapidly gelatinized at the proximal and the distal ends than at the sides, while the primary starch is gelatinized before the secondary instead of afterwards, as is often the case in *N. emperor*. In the second method, which is also similar in some respects to that seen in *N. emperor*, 2 furrows or fissures extend transversely or obliquely from the hilum on either side to the margin, and from this point the reaction is the same as in *N. emperor*, except that there is no distinction between primary and secondary starch, and the band of resistant material at the margin is formed only at the proximal end and not all around the margin as in *N. emperor*. The grains are all gelatinized before they are dissolved. The gelatinized grains are more swollen, have thinner capsules, and are somewhat more distorted than in *N. emperor*.

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 20 per cent of the total starch in 15 minutes; in about 47 per cent of the grains and 74 per cent of the total starch in 30 minutes; in about 60 per cent of the grains and 82 per cent of the total starch in 45 minutes; and in about 70 per cent of the grains and 93 per cent of the total starch in 60 minutes. (Charts D 343 and D 344.)

The hilum becomes distinct, unattended by the formation of a bubble. The lamellæ are distinct and evidence of a lamellar structure persists throughout the greater part of the reaction. Gelatinization begins at the hilum, and in nearly all the grains proceeds according to but one method. The primary starch immediately surrounding the hilum is split into four or five portions, which are in turn subdivided into a number of rather fine, refractive granules which are widely scattered as the grain swells. The secondary deposit surrounding the primary starch is divided by fine striæ, and as the less resistant starch is gelatinized the more resistant portion is pushed to the margin, where it forms a finely striated and distinctly lamellated band, around the inner border of which are scattered the granules of the primary starch which remain ungelatinized until the secondary starch is gelatinized. The marginal band is gelatinized more rapidly at the distal end and last at the proximal end. In a few grains, 2 furrows or fissures extend from the hilum on either side of the margin. The material distal to them becomes finely granular and gelatinizes slowly; the proximal material forms a homogeneous-looking band at the proximal margin and remains ungelatinized. The gelatinized grains are considerably swollen, have rather thick capsules, and are somewhat distorted.

Comparison of the *pyrogallic-acid* reactions between *N. triandrus albus* and *N. emperor* shows:

The hilum and lamellæ are not quite so distinct as in *N. emperor*. Gelatinization progresses according to three methods instead of but two as in *N. emperor*. The first, which is seen in a large number of grains, corresponds with that which is described for a very few grains of *N. emperor*, the only difference being that the material proximal to the 2 furrows or fissures which extend transversely or obliquely from either side of the hilum to the margin forms a homogeneous-looking band at the proximal margin instead of being covered by fine striæ. The second method, which is seen in a large number of the remaining grains, is not noted in *N. emperor*. The hilum enlarges somewhat, and the grain is covered by fine striæ, and gelatinizes and swells slowly; the more resistant material forms a finely striated band at the margin which very slowly becomes thinner and more nearly transparent until it is completely gelatinized. The third method, which is seen in an equal number of grains as the second, corresponds with that described for the great majority of the grains of *N. emperor;* the only differences noted are that the granules into which the primary starch is divided are larger and more refractive, and the striæ in the secondary starch are not so fine and more distinct. The gelatinized grains are more swollen, the capsules are not so thick, and they are more distorted than in *N. emperor*.

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 16 per cent of the grains and 51 per cent of the total starch in 15 minutes; in about 31 per cent of the grains and 62 per cent of the total starch in 30 minutes; in about 35 per cent of the grains and 65 per cent of the total starch in 45 minutes; and in about 37 per cent of the grains and 67 per cent of the total starch in 60 minutes. (Chart D 345.)

The hilum is distinct and occasionally a bubble is formed there immediately after the reagent is added, but it soon shrinks and disappears. The lamellæ are distinct, and evidence of a lamellar structure remains throughout the greater part of the reaction. Gelatinization begins at the hilum and in nearly all the grains progresses by one method. The material immediately surrounding the hilum, which probably represents a primary starch formation, is split into several particles which are usually subdivided and scattered as the grain swells, but which sometimes remain clumped together in their original position while the rest of the grain is gelatinized. In the meantime, the material surrounding the primary starch, which probably represents a secondary starch formation, is first divided by fine striæ, and as the less resistant portion is gelatinized the more-resistant material is pushed to the margin, where it forms a finely striated and distinctly lamellated band, around the inner border of which are usually arranged the particles of the primary starch. The marginal band at the distal end is

invaded by several longitudinal fissures and the material here is formed into an irregular, nearly transparent fissured mass which persists for a long time after the rest of the grain is completely gelatinized. In the meantime, the rest of the starch forming the marginal band becomes gradually thinner and more nearly transparent and loses its striated appearance, but retains the lamellated appearance until gelatinization is nearly complete. The proximal end of this marginal band is the last to be gelatinized. The particles of the primary starch are very resistant, but gradually grow smaller and more refractive and finally disappear. The gelatinized grains are much swollen and have rather thick capsules. They are somewhat distorted, but retain some resemblance to the form of the untreated grain.

Comparison of the *nitric-acid* reactions between *N. triandrus albus* and *N. emperor* shows:

The hilum is as distinct, but the lamellæ are neither so distinct nor so persistent, as in *N. emperor.* Gelatinization follows three methods of procedure instead of but one. That noted in a number of the grains is not at all the same as that seen in practically all the grains of *N. emperor.* Two furrows or fissures extend transversely or obliquely from either side of the hilum to the margin, and the material included between them is divided into fine granules and then criss-crossed by irregular fissures. After the division into granules this material is gelatinized, with much swelling and considerable distortion of the capsule. The more resistant material at the proximal end is divided by coarse striæ and pushed to the margin, where it gradually gelatinizes as the grain swells. The second method is very similar to that described in *N. emperor,* except that there is no distinction between primary and secondary starch, and the behavior of the whole grain is the same as that described for the secondary starch. In the third method there are both primary and secondary starches, and the reaction is very similar to that described under *N. emperor,* the main differences noted being that the striæ are not so fine and are more distinct, and the particles of the primary starch are smaller and more refractive, than in *N. emperor.*

The gelatinized grains are more swollen and the capsules are not so thick as in *N. emperor.* They are somewhat more distorted and bear more resemblance to the form of the untreated grain.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 80 per cent of the entire number of grains and 94 per cent of the total starch in 2 minutes, and in about 98 per cent of the grains and more than 99 per cent of the total starch in 5 minutes. (Chart D 346.)

The hilum becomes distinct, attended by the formation of a large bubble in a moderate number of grains. The lamellæ are usually obscured, but in some grains become distinct for a short period in the course of the reaction. Gelatinization begins in the interior of the grains and proceeds according to two methods which are, however, very much alike. In the first which is seen in a large majority of the grains, 2 furrows or actual fissures extend transversely or obliquely from either side of the hilum to the margin, and the material surrounding the hilum which represents primary starch, is separated from the rest by a refractive fissure. Then all the starch distal to the hilum and to the 2 furrows becomes homogeneous in appearance and more refractive, and gelatinizes very rapidly, the primary as rapidly as the secondary, with much swelling and considerable distortion of the capsule. Meanwhile the portion at the proximal end is not affected, and as the distal material swells it forms a homogeneous-looking, refractive band at the proximal margin. Here it is later gelatinized comparatively slowly. The second method is very much like the first, the only difference being that the portion of the grain immediately surrounding the hilum, which represents a primary starch formation and which exists in many of the grains which are gelatinized by the first method, but is not differentiated from the secondary starch, is partially separated from the rest of the grain by a refractive fissure and gelatinizes somewhat more slowly than the rest of the distal material, but in the same way and much more rapidly than the proximal portion. The gelatinized grains are much swollen, have rather thin capsules, and are considerably distorted.

Comparison of the *sulphuric-acid* reactions between *N. triandrus albus* and *N. emperor* shows:

A bubble is formed at the hilum much more often than in *N. emperor,* and the lamellæ are usually obscured during all of the reaction, as in *N. emperor.* Gelatinization proceeds according to two methods, of which one (seen in a small majority of the grains) is not noted in *N. emperor.* The primary starch immediately surrounding the hilum is partially separated from the secondary starch by a refractive fissure and becomes granular, and is then divided into three or four pieces by the swelling of the bubble at the hilum. The secondary starch becomes homogeneous-looking and refractive and gelatinizes very rapidly, with much swelling and distortion of the capsule; the portions of the primary starch meanwhile are widely separated and gelatinize more slowly. The second method, which is seen in a large minority, is the same as that found in a large majority of the grains of *N. emperor.* The gelatinized grains are more swollen, the capsules are thinner, and they are more distorted than in *N. emperor.*

Narcissus J. T. Bennett Poe (Hybrid).

(Plate 15, fig 87; Charts D 341 to D 346.)

Histologic Properties.

In *form* the grains are usually simple and isolated, and there are fewer compound grains and aggregates than in either parent, in this respect showing a closer resemblance to *N. emperor* than to *N. triandrus albus.* The compound grains belong to the two types noted under both parents, but tend to have, as in *N. triandrus albus,* more components than in *N. emperor.* The aggregates are of the same types as in *N. emperor,* and aggregates of compound and simple grains, and of compound grains only, are seen which are not present in *N. triandrus albus.* Simple grains, showing a clear distinction between primary and secondary starch formations, are seldom seen as in *N. triandrus albus.* The grains are as irregular as in *N. emperor,* and the irregularities are due to the same causes as in that starch. The conspicuous forms are broad and slender ovoid, lenticular, broad elliptical, and clam-shell-shaped. The additional forms are reniform, pyriform, triangular with curved base and rounded angles, irregularly quadrilateral with rounded angles, and dome-shaped.

In form *N. j. t. bennett poe* shows a closer relationship to *N. emperor* than to *N. triandrus albus.*

The *hilum,* when not fissured, is as distinct as in *N. emperor.* It is less often fissured than in either parent; in frequency of fissuration it shows a closer relationship to *N. emperor,* and the fissures have the same forms as in this starch. The hilum is sometimes centric, but in the majority of the grains it is eccentric from 0.45 to 0.3, usually 0.36, of the longitudinal axis.

In the character and eccentricity of the hilum *N. j. t. bennett poe* shows a somewhat closer relationship to *N. emperor* than to *N. triandrus albus.*

The *lamellæ* are more often distinct than in either parent, and in this the hybrid shows a closer resemblance to *N. triandrus albus.* They are, as in *N. triandrus albus,* fine continuous rings which have the same characteristics and arrangements as in that starch. In the character of the lamellæ *N. j. t. bennett poe* shows a closer relationship to *N. triandrus albus* than to *N. emperor.*

In *size* the grains vary from the smaller which are 3 by 3μ, to the larger broad forms which are 32 by 46μ, and the larger elongated forms which are 44 by 36μ, in length and breadth. The common sizes are 28 by 30μ and 28 by 20μ. In size *N. j. t. bennett poe* shows a somewhat closer relationship to *N. emperor* than to *N. triandrus albus.*

Polariscopic Properties.

The *figure* is as distinct and as well defined as in *N. triandrus albus.* The lines, as in *N. triandrus albus,* often cross at a right angle and in other grains at an acute angle which does not vary much in size, and they are usually not bent and only occasionally bisected. There are as few grains, as in *N. triandrus albus,* in which the figure has the form of a conjugate hyperbola, or of a long line bisected at both ends.

The *degree of polarization* varies from low to high (value 60), the same as in *N. triandrus albus,* and there is as little variation in different parts of a given aspect of the individual grains.

With *selenite* the quadrants as in *N. triandrus albus* are usually clear-cut and regular in form. The colors are usually not pure, and there are but few grains in which the colors have a greenish tinge.

In the degree of polarization, the character of the figure, and the appearances with selenite, *N. j. t. bennett poe* shows a closer relationship to *N. triandrus albus* than to *N. emperor.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate to deep violet tinged with blue (value 60), the same as in *N. emperor.* With 0.125 per cent Lugol's solution the grains all color a light to moderate violet tinged with blue, the same as in *N. emperor.* After heating in water until the grains are all gelatinized, the gelatinized *grains* all color a moderate indigo, and the *solution* a deep indigo, as in both parents. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the *grain-residues* all color a light indigo, the *capsules* a red or a reddish violet, and the *solution* a very deep indigo-blue, as in both parents.

Qualitatively and quantitatively the iodine reactions of the unheated grains show a closer relationship to *N. emperor* than to *N. triandrus albus.* The iodine reactions of the gelatinized and boiled grains show no differences between the parents and the hybrid.

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes they are all moderately colored (value 50), more than in either parent, but nearer to *N. emperor.*

With *safranin* the grains all color very lightly at once, and in half an hour they are moderately colored (value 55), more than in either parent but closer to *N. emperor.*

In the reactions with aniline stains *N. j. t. bennett poe* shows a closer relationship to *N. emperor* than to *N. triandrus albus.*

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 64° to 64.8° C., and of all 69° to 71° C., mean 70° C.

The temperature of gelatinization of *N. j. t. bennett poe* is lower than that of either parent and differs from both much more than they do from one another, but is somewhat closer to that of *N. triandrus albus* than to that of *N. emperor.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 8 per cent of the total starch in 15 minutes; in about 10 per cent of the grains and 20 per cent of the total starch in 30 minutes; in about 20 per cent of the grains and 24 per cent of the total starch in 45 minutes; and in about 28 per cent of the grains and 32 per cent of the total starch in 60 minutes. (Chart D 341.)

The hilum becomes distinct, accompanied by the formation of a bubble in a smaller number of grains than in *N. emperor* and in many less than in *N. triandrus albus.* The lamellæ, which at first are not visible, later become as distinct as in *N. emperor.* The grains become as refractive as in both parents after the addition of the reagent. Gelatinization begins at the distal margin or at the proximal end, and then at the distal end, as in *N. emperor,* and progresses according to the two methods described under both parents. In the first method, which is seen in a majority of the grains, gelatinization progresses as in *N. emperor,* the only differences noted being that there was some irregular fissuring and breaking away of small particles from the ungelatinized starch and not so often a separation into two pieces of the material just distal to the hilum by a longitudinal fissure. In the second method no differences are to be noted between the hybrid and *N. emperor.* The gelatinized grains are as much swollen, have as thin capsules, and are as distorted as in *N. emperor.* In this reaction *N. j. t. bennett poe* shows qualitatively a closer relationship to *N. emperor* than to *N. triandrus albus.*

The reaction with *chromic acid* begins in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 16 per cent of the

grains and 51 per cent of the total starch in 15 minutes; in about 43 per cent of the grains and 87 per cent of the total starch in 30 minutes; in about 57 per cent of the grains and 95 per cent of the total starch in 45 minutes; and in about 88 per cent of the grains and in more than 99 per cent of the total starch in 60 minutes. (Chart D 342.) (See footnote, page 516.)

The hilum and lamellæ are more distinct than in either parent, and in this characteristic the grains more closely resemble those of *N. emperor* than those of *N. triandrus albus.* Gelatinization begins at the hilum and proceeds according to two methods, of which that recorded in the majority of the grains is the same as that seen in all the grains of *N. emperor,* and that found in a minority of the grains resembles closely that seen in a minority of the grains of *N. triandrus albus,* the differences noted being that the striæ which divide the proximal starch are not so coarse and that there is more and more irregular fissuring of the portion distal to the 2 furrows which extend horizontally from the hilum. Only a few grains as in *N. emperor* are dissolved before gelatinization is complete. The gelatinized grains are as much swollen, have as thin capsules, and are no more distorted than in *N. triandrus albus.*

In this reaction *N. j. t. bennett poe* shows qualitatively a somewhat closer relationship to *N. triandrus albus* than to *N. emperor.*

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 20 per cent of the total starch in 5 minutes; in about 10 per cent of the grains and 60 per cent of the total starch in 15 minutes; in about 60 per cent of the grains and 85 per cent of the total starch in 30 minutes; in about 75 per cent of the grains and 95 per cent of the total starch in 45 minutes; and in about 85 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 343.)

The hilum and lamellæ are more distinct than in either parent. Gelatinization begins at the hilum and proceeds according to two methods, which are very similar to the two methods described in *N. emperor.* The first, which is seen in a large majority of the grains, corresponds with that found in a still larger majority of the grains of *N. emperor* and in a moderate number of the grains of *N. triandrus albus.* The differences noted between these grains and those of *N. emperor* are the same as those in *N. triandrus albus.* Those of the primary starch are not so large and are more refractive, and the striæ which divide the secondary starch are not so fine but more distinct. In the few grains in which the second method is seen it is exactly like that described in *N. triandrus albus.* The gelatinized grains are more swollen, have thinner capsules, and are more distorted than in either parent, in this respect more nearly resembling *N. triandrus albus* than *N. emperor.*

In this reaction *N. j. t. bennett poe* shows in certain respects a somewhat closer relationship to *N. triandrus albus* than to *N. emperor,* and in others the reverse.

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 15 per cent of the total starch in 5 minutes; in about 24 per cent of the grains and 57 per cent of the total starch in 15 minutes; in about 33 per cent of the grains and 63 per cent of the total starch in 30 minutes; in about 39 per cent of the grains and 69 per cent of the total starch in 45 minutes; and in 43 per cent of the grains and 72 per cent of the total starch in 60 minutes. (Chart D 345.)

The hilum and lamellæ are more distinct than in either parent. Gelatinization begins at the hilum and progresses according to two methods. The great majority are gelatinized according to two methods, which correspond closely to that described for practically all the grains of *N. emperor* and for a moderate number of the grains of *N. triandrus albus.* The differences are that the striæ which divide the secondary starch are not so fine, and the particles into which the primary starch is divided are, when scattered, not so large and are more refractive, but show more tendency to remain clumped in the center of the grain than in *N. emperor.* A small minority of the grains follow closely the method described for a number of the grains of *N. triandrus albus,* but the granules formed from the distal material are not so large nor so distinct and the primary deposit is not so resistant as in *N. triandrus albus.* The gelatinized grains are more swollen, and have thinner capsules, and are more distorted, than in either parent. In this respect the hybrid is closer to *N. triandrus albus* than to *N. emperor.*

In this reaction *N. j. t. bennett poe* shows in certain respects qualitatively a closer resemblance to *N. triandrus albus* than to *N. emperor,* and in others the reverse.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 90 per cent of the entire number of grains and 99 per cent of the total starch in 2 minutes, and in about 98 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 346.)

The hilum becomes distinct, accompanied by the formation of a small bubble more often than in either parent, in which respect the hybrid is closer to *N. triandrus albus.* The lamellæ, as in both parents, are obscured throughout the reacton. Gelatinization begins in the interior of the grain and progresses according to two methods, of which that found in a great majority of the grains is the same as that seen in a great majority of those of *N. emperor.* The second method which is noted in but few grains, resembles closely that described in a majority of the grains of *N. triandrus albus,* the only difference noted being that the primary starch does not become granular before its division into several pieces, and these pieces gelatinize more nearly at the same time as the secondary starch. The gelatinized grains are more swollen, have thinner capsules, and are more distorted than in either parent. In this respect the hybrid is closer to *N. triandrus albus* than to *N. emperor.*

In this reaction *N. j. t. bennett poe* shows qualitatively, a somewhat closer relationship to *N. emperor* than to *N. triandrus albus.*

7. LILIUM.

The genus *Lilium* comprises no less than 50 known species, a large number of varieties, and many hybrids. The genus is commonly recognized as consisting of 6 subgenera, of which only 2 are represented in this research—subgenus *Eulirion* by *L. candidum* Linn. and *L. parryi* Wats., and subgenus *Martagon* by *L. martagon* Linn. (*L. dalmaticum* Vis.), *L. martagon album* (a horticultural variety of *L. martagon*), *L. pardalinum* Kellogg (*L. californicum* Domb.), *L. maculatum* Thunb. (*L. hansoni* Leicht.), *L. testaceum* Lind. (*L. isabellinum* Kurze; *L. excelsum* Hort.), *L. tenuifolium* Fisch., and *L. chalcedonicum* Linn.

Starches of the following five sets of parent- and hybrid-stocks were studied, all of the bulbs, with the exception of those of *L. tenuifolium* and the hybrid *L. golden gleam*, being obtained from Barr & Sons, London, and the latter from Mr. George C. Richmond, Le Roy, New York, the originator of the hybrid:

25. *L. martagon album* (seed parent), *L. maculatum* (pollen parent), and *L. marhan* (hybrid), page 598.
26. *L. martagon* (seed parent), *L. maculatum* (pollen parent), and *L. dalhansoni* (hybrid), page 606.
27. *L. tenuifolium* (seed parent), *L. martagon album* (pollen parent), and *L. golden gleam* (hybrid), page 612.
28. *L. chalcedonicum* (seed parent), *L. candidum* (pollen parent), and *L. testaceum* (hybrid), page 619.
29. *L. pardalinum* (seed parent), *L. parryi* (pollen parent), and *L. burbanki* (hybrid), page 627.

It will be observed that in the first three sets the crosses were between members of the same subgenus (*Martagon*), and in the last two sets between members of two subgenera (*Martagon* and *Eulirion*).

25. Starches of Lilium martagon album, L. maculatum, and L. marhan.

Lilium martagon album (Seed Parent).

(Plates 15 and 16, figs 88 and 95; Charts D 347 to D 353.)

Histologic Properties.

In *form* the grains are usually simple and isolated. A few compound grains and aggregates are seen. The compound grains belong to one type: 2 very small grains, each consisting of a hilum and 1 or 2 lamellæ, become adherent and attached to the proximal end of a long grain and surrounded by 20 to 30 common secondary lamellæ. The aggregates are in the form of doublets or triplets pyramidally arranged. The grains are usually regular in form, and any irregularities which may occur are due to the following causes: (1) Small, irregular elevations and depressions of the distal surface and margin; (2) a shifting of the longitudinal axis, with a consequent curvature at the middle or distal end of the grain; (3) a rather large, rounded protuberance from the proximal end or from either side; (4) a greater development of one part of the distal end than of the rest. The conspicuous forms are elongated ovoid, with a squared or rounded distal end, broad and narrow pyriform, club-shaped, narrow, triangular, and mussel-shell-shaped. The additional forms are elliptical, finger-shaped, nearly round, lenticular, and dome-shaped. The broad forms are somewhat flattened, and when viewed on edge they have an elongated, ovoid form.

The *hilum* is usually a moderately distinct, small, round, or lenticular spot. It is often fissured and is sometimes occupied by a cavity from either side of which 2 delicate fissures radiate towards the corners of the distal margin. When fissuration occurs the fissures have the following forms: (1) A single, short, transverse line; (2) a flying-bird figure. The hilum is eccentric from 0.3 to 0.1, usually 0.22, of the longitudinal axis.

The *lamellæ* are usually fine and not very distinct. Those near the hilum are continuous, round, or ovoid rings. Those in the other parts of the grain have in general the form of the outline of the grain, and when near the distal end are not so fine, more distinct, and probably not continuous. In many grains there is 1 broad, refractive lamella situated from two-thirds to three-fourths of the distance from the hilum to the distal end. While in other grains there are 2 to 5 broad refractive lamellæ which divide the fine lamellæ into groups of varying breadth. The number counted on the larger grains varies from 30 to 52, usually 42.

In *size* the grains vary from the smaller which are 5 by 4μ, to the larger which are 68 by 38μ, rarely 76 by 34μ, in length and breadth. The common size is 30 by 19μ.

Polariscopic Properties.

The *figure* is distinct and well defined. The lines are fine and intersect at an acute angle which does not vary in size in the different grains. They are usually straight, but sometimes bent and occasionally bisected.

The *degree of polarization* varies from low to high (value 65). In most of the grains it is moderate or high, and in a few it is low. There is occasionally some variation in a given aspect of an individual grain.

With *selenite* the quadrants are clear-cut, and very unequal in size, and usually regular in shape. The colors are usually pure, the blue more often than the yellow. In some grains there is a greenish tinge.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate to high blue-violet (value 65). The color deepens very rapidly until it is very deep and has more of a bluish tint. With 0.125 per cent Lugol's solution the grains all color a light to moderate blue-violet, and the color deepens very rapidly until it is deep and has more of a bluish tint. After heating in water until the grains are all gelatinized and then adding a 2 per cent Lugol's solution, most of the gelatinized *grains* color a light and some a moderate indigo-blue, and the *solution* a deep indigo-blue. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the *grain-residues* all color light indigo, the *capsules* a red or a reddish violet, and the *solution* a very deep indigo.

Aniline Reactions.

With *gentian violet* the grains all color very lightly in a minute, and in 30 minutes most of the grains are moderately and a few are deeply colored (value 55). The grains are usually colored more at the distal than at the proximal end.

With *safranin* the grains all color very lightly in a minute, and in 30 minutes most of the grains are moderately and a few deeply colored (value 50). The grains are usually colored more at the distal than at the proximal end.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 59° to 61° C., and of all is 62° to 64° C., mean 63° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 30 seconds. Complete gelatinization occurs in about 23 per cent of the entire number of grains and 47 per cent of the total starch in 5 minutes; in about 70 per cent of the grains and 88 per cent of the total starch in 15 minutes; and in about 94 per cent of the grains and 97 per cent of the total starch in 30 minutes. (Chart D 347.)

The hilum becomes distinct, attended by the formation of a bubble in but few grains. The lamellæ are not visible. The grains become more refractive after the addition of the reagent, and the first part of the grain to be affected is a broad strip at the margin. Gelatinization usually begins at the corners of the distal margin, and then quickly at the proximal end, with swelling of the hilum, but in a moderate number of grains it begins first at the proximal end and then at the distal end. It progresses by but one method, and it is preceded by shallow indentations in the margin and a pitted appearance of the surface of the ungelatinized portions of the grain. It progresses regularly from either end of the grain, and the last part to be gelatinized is just distal to the hilum, being split, becoming widely separated, and gelatinizing independently of one another. The gelatinized grains are much swollen, have rather thick capsules, and are greatly distorted. They do not retain any resemblance to the form of the untreated grain.

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 53 per cent of the entire number of grains and 82 per cent of the total starch in 3 minutes; in about 70 per cent of the grains and 90 per cent of the total starch in 5 minutes; in about 87 per cent of the grains and 97 per cent of the total starch in 15 minutes; in more than 99 per cent of the grains and total starch in 30 minutes. (Chart D 348.)

The hilum becomes distinct in all the grains, attended by the formation of a bubble in but few grains. The lamellæ are distinct. Gelatinization begins at the hilum, which swells rapidly, more rapidly in the direction of the proximal than the distal end. Two short fissures extend from the hilum on either side not more than half the distance toward the distal end, and the material included between them is distinctly and irregularly fissured. As gelatinization proceeds and the grain swells these fissures separate off spicules of starch which later become refractive granules and which later unite to form a very irregular granular mass at the distal end. The starch at the proximal end and sides nearby forms a homogeneous-looking refractive band at the margin which is thinner at the proximal end than elsewhere. Solution occurs at this point and progresses distally, the distal marginal deposit being the last to be dissolved and the granular portion at the distal end the next to the last.

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 40 per cent of the entire number of grains and 90 per cent of the total starch in 5 minutes, and in about 81 per cent of the grains and 95 per cent of the total starch in 15 minutes. (Charts D 349 and D 350.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 98 per cent of the entire number of grains and 99 per cent of the total starch in 15 seconds, and in more than 99 per cent of the grains and total starch in 30 seconds. The rare grains ungelatinized in 30 seconds are very resistant and may resist gelatinization for 5 minutes and longer.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 78 per cent of the entire number of grains and 90 per cent of the total starch in 30 seconds, and in about 96 per cent of the grains and 99 per cent of the total starch in 1 minute; very rare grains remain ungelatinized for 5 minutes or longer.

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 95 per cent of the entire number of grains and 98 per cent of the total starch in 15 seconds, and in more than 99 per cent of the grains and total starch in 30 seconds; very rare ungelatinized grains resist the reaction for 5 minutes or longer.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in more than 99 per cent of the entire number of grains and total starch in 15 seconds. Rare grains are quite resistant.

The hilum becomes distinct in all the grains, unattended in any by the formation of a bubble. The lamellæ are moderately distinct. Gelatinization begins at the hilum, which swells more rapidly toward the proximal end than toward the distal end of the grain. Two fissures which are continued as furrows extend from either side of the hilum three-fourths of the distance from the hilum to the distal margin. The starch included between them is fissured irregularly and rather indistinctly at first. As the grain swells it grows less and less in amount and more and more distinctly fissured until near the end of the reaction when all is gelatinized but a small, irregular, refractive mass at the distal end, which slowly gelatinizes with considerable infolding and other distortions of the capsule. In the majority of the grains this is the last part to be gelatinized. The starch at the proximal and distal margins and sides forms a thick, homogeneous-looking refractive band which grows thinner and more nearly transparent until it is completely gelatinized and only the capsule is left. The gelatinized grains are much swollen, have rather thin capsules, and are considerably distorted, especially at the distal end.

(The solution of KOH used for the time reactions of the lilies was diluted for the qualitative work, so that it represented a solution of 0.28 gram KOH in 55 c.c. H_2O instead of 0.75 gram KOH in 55 c.c. H_2O.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 84 per cent of the entire number of grains and 97 per cent of the total starch in 30 seconds; in about 95 per cent of the grains and 99 per cent of the total starch in 1 minute; and in about 97 per cent of the grains and in more than 99 per cent of the total starch in 3 minutes. Rare

scattered grains are quite resistant and may remain ungelatinized for 5 minutes or longer.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 80 per cent of the entire number of grains and 87 per cent of the total starch in 15 seconds; in about 92 per cent of the grains and 95 per cent of the total starch in 30 seconds; and in about 97 per cent of the grains and in more than 99 per cent of the total starch in 1 minute. Rare scattered grains remain ungelatinized for 5 minutes or longer.

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in more than 99 per cent of the entire number of grains and total starch in 15 seconds. Very rare resistant grains remain for 5 minutes or longer.

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs, in all but rare grains, in more than 99 per cent of the grains and total starch in 15 seconds. Rare resistant grains remain ungelatinized for 5 minutes and longer.

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 90 per cent of the entire number of grains and 98 per cent of the total starch in 15 seconds; in about 96 per cent of the grains and 99 per cent of the total starch in 30 seconds; and in more than 99 per cent of the grains and total starch in 45 seconds. Rare resistant grains remain ungelatinized for 5 minutes or longer.

The reaction with *sodium salicylate* begins in 30 seconds. Complete gelatinization occurs in about 28 per cent of the entire number of grains and 53 per cent of the total starch in 3 minutes; in about 71 per cent of the grains and 84 per cent of the total starch in 5 minutes; and in about 97 per cent of the grains and 99 per cent of the total starch in 10 minutes. (Chart D 352.)

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 55 per cent of the entire number of grains and 85 per cent of the total starch in 1 minute; in about 85 per cent of the grains and 97 per cent of the total starch in 3 minutes; and in about 97 per cent of the grains and 98 per cent of the total starch in 5 minutes.

The reaction with *uranium nitrate* begins in 30 seconds. Complete gelatinization occurs in about 57 per cent of the entire number of grains and 66 per cent of the total starch in 1 minute, and in about 97 per cent of the grains and 99 per cent of the total starch in 3 minutes.

The reaction with *strontium nitrate* begins in 15 seconds. Complete gelatinization occurs in about 57 per cent of the entire number of grains and 73 per cent of the total starch in 1 minute, and in about 98 per cent of the grains and 99 per cent of the total starch in 3 minutes.

The reaction with *cobalt nitrate* begins in a few grains in 15 seconds. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 17 per cent of the total starch in 1 minute; in about 72 per cent of the grains and 87 per cent of the total starch in 3 minutes; in about 82 per cent of the grains and 95 per cent of the total starch in 5 minutes; and in about 95 per cent of the grains and 98 per cent of the total starch in 15 minutes.

The hilum becomes distinct in all the grains, attended by the formation of a bubble in a moderate number. The lamellæ are distinct. Gelatinization begins at the hilum, which enlarges rapidly, especially toward the proximal end, which is at first invaginated and later pushed out. Two fissures extend obliquely from either side of the hilum nearly to the distal margin and the deposit comprehended between them is first divided by fine longitudinal and oblique fissures, which as the grain swells separate it into spicules. As the grain continues to swell this material is pushed to the distal end and it, together with the portion at the distal margin, is divided by wedge-shaped fissures into a serrated border. Meanwhile, the starch at the proximal end and sides forms a refractive marginal band which shows 2 or 3 faint lamellar markings. It gradually loses this lamellated appearance and becomes thinner and more nearly transparent, until it is completely gelatinized and only the capsule is left. The granular serrated material at the distal end gradually grows more nearly transparent and is finally gelatinized, with considerable distortion and infolding of the capsule at this point. The gelatinized grains are much swollen, have rather thin capsules, and are very much distorted at the distal end and very little distorted at the proximal end.

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 55 per cent of the entire number of grains and 75 per cent of the total starch in 1 minute, and in about 97 per cent of the grains and 99 per cent of the total starch in 3 minutes.

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 55 per cent of the entire number of grains and 77 per cent of the total starch in 1 minute, and in about 94 per cent of the grains and 99 per cent of the total starch in 3 minutes.

The hilum becomes distinct in all the grains, attended by the formation of a bubble in the majority of the grains. The lamellæ become distinct. Gelatinization begins at the hilum, which swells more rapidly in the direction of the proximal than the distal end. Two fissures extend obliquely from either side of the hilum about one-half to three-fourths of the distance between the hilum and the distal margin. The material included between them is first divided by very fine and rather indistinct fissures. The portion just distal to the hilum is then divided into spicules or bundles of spicules by a double row of fissures which slant proximally from the 2 fissures proceeding from either side of the hilum to the longitudinal axis of the grain. These spicules are gelatinized first and leave a residue of scattered refractive granules. The remainder of the fissured portion is partially gelatinized, and as the grain swells the rest of this part forms a small, irregularly granular residue, at the distal end of the grain which is usually gelatinized before the marginal portion of the grain. The deposit at the proximal and distal margins and sides forms a refractive, homogeneous-looking band which is rather thick at first and gradually grows thinner and more nearly transparent until it is completely gelatinized, leaving only the capsule. The gelatinized grains are very much swollen, have rather thick capsules, and are somewhat distorted, particularly at the distal end.

The reaction with *barium chloride* begins in a few grains in 30 seconds. Complete gelatinization occurs in

about 3 per cent of the entire number of grains and 10 per cent of the total starch in 1 minute; in about 53 per cent of the grains and 76 per cent of the total starch in 3 minutes; in about 62 per cent of the grains and 81 per cent of the total starch in 5 minutes; in about 87 per cent of the grains and 92 per cent of the total starch in 15 minutes; and in about 90 per cent of the grains and 95 per cent of the total starch in 30 minutes. (Chart D 353.)

The reaction with *mercuric chloride* begins immediately. Complete gelatinization occurs in about 45 per cent of the entire number of grains and 63 per cent of the total starch in 30 seconds; in about 78 per cent of the grains and 91 per cent of the total starch in 1 minute; and in about 98 per cent of the grains and in more than 99 per cent of the total starch in 3 minutes.

Lilium maculatum (Pollen Parent).

(Plates 15 and 16, figs. 89 and 92; Charts D 347 to D 353.)

Histologic Properties.

In *form* the grains are usually simple and isolated. There are fewer compound grains and aggregates than in *L. martagon album.* The compound grains belong to the same type as in that starch. The grains are usually regular, but somewhat more often irregular than in *L. martagon album.* The irregularities are due to the same causes as in that starch, to which may be added that caused by a secondary set of lamellæ whose longitudinal axis is at right angle with those of the primary grain. The conspicuous forms are narrow and broad pyriform, elongated ovoid, narrow and broad triangular with curved base and rounded angles, and clam-shell-shaped. The additional forms are elongated elliptical with squared distal end, almost round, and dome-shaped. The forms of the grains are somewhat less varied, broader, and less pointed than in *L. martagon album.* As in that starch, the broad forms are somewhat flattened, and when viewed on edge have an elongated ovoid form.

The *hilum* is more distinct than in *L. martagon album,* and much more often fissured. It is, however, somewhat less often occupied by a cavity than in that starch. The fissures have the form of a single, short, straight, transverse line, which is also seen in *L. martagon album.* The hilum is eccentric from 0.32 to 0.1, usually 0.15, of the longitudinal axis. It is somewhat more eccentric than that of *L. martagon album.*

The *lamellæ* are less fine and somewhat more distinct than in *L. martagon album;* otherwise they have the same characteristics and arrangements as in that starch. The number counted on the larger grains varies from 30 to 58, usually 38, less numerous than in *L. martagon album.*

In *size* the grains vary from the smaller which are 5 by 4μ in length and breadth, to the larger elongated forms which are 50 by 36μ, and the larger broader forms which are 50 by 55μ and 50 by 48μ, in length and breadth. The common sizes are 30 by 24μ and 28 by 20μ in length and breadth. On the whole, they are broader absolutely and proportionately to length than in the other parent.

Polariscopic Properties.

The *figure* is as distinct but often not quite so well defined as in *L. martagon album.* The lines are not so thin, and form a more acute angle at their intersection. They are, as in *L. martagon album,* not often bent, and rarely bisected.

The *degree of polarization* varies from low to high (value 50), much less than in *L. martagon album,* as there were fewer grains in which it was high and more in which it was moderate. There is less variation in a given aspect of an individual grain than in that starch.

With *selenite* the quadrants are not so clear-cut, and are somewhat more unequal in size, but no more irregular in shape than in *L. martagon album.* The colors, unlike those of the grains of *L. martagon album,* are usually not pure.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate blue-violet (value 55), less than in *L. martagon album.* The color deepens rapidly until it is very deep and has more of a bluish tint. With 0.125 per cent Lugol's solution the grains all color a light blue-violet, less than in *L. martagon album,* and the color deepens rapidly until it is deep and has assumed more of a bluish tint. After heating in water until all the grains are completely gelatinized and then treating with a 2 per cent Lugol's solution, most of the gelatinized *grains* color a light indigo, less than in *L. martagon album,* and some do not color at all and the *solution* colors a very deep indigo, more than with *L. martagon album.* If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, a moderate number of the *grain-residues* color a very light indigo, less than in *L. martagon album,* and the greater number do not color at all except the capsules. The *capsules* all color a reddish violet or violet instead of red or reddish violet as in *L. martagon album,* and the *solution* is colored a very deep indigo.

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes most of the grains are lightly to moderately and a few moderately to deeply colored (value 45), less than in *L. martagon album.* The grains are colored more at the distal end than at the proximal end.

With *safranin* the grains all color very lightly at once, and in 30 minutes they are lightly to moderately or moderately to deeply colored (value 45), less than in *L. martagon album.* The grains are colored more at the distal than the proximal end.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 57° to 58° C., and of all is 60° to 62° C. The mean is 61° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 30 seconds. Complete gelatinization occurs in about 40 per cent of the entire number of grains and 82 per cent of the total starch in 5 minutes; in about 82 per cent of the grains and 97 per cent of the total starch in 15 minutes; and in more than 99 per cent of the grains and total starch in 30 minutes. (Chart D 347.)

The hilum becomes distinct, attended by the formation of a bubble in a large minority of the grains—many more than in *L. martagon album.* The lamellæ are not visible. The grains become more refractive; the first part

to show this change is a rather narrow strip of starch at the margin which is not so refractive as in *L. martagon album.* Gelatinization as in *L. martagon album* begins at the corners of the distal margin, and in many grains at the proximal end immediately afterwards. In some grains, however, the proximal end is not gelatinized until all of the distal half is gelatinized. Gelatinization is preceded by small, irregular fissures which invade the ungelatinized material and so open it to invasion by the reagent; at these points there is gelatinization, and great hollows are formed in the ungelatinized starch. Gelatinization proceeds more rapidly along the margin than in the interior of the grain, and the portion just distal to the hilum is the last to be gelatinized. This is not split into two pieces as in *L. martagon album,* but is gelatinized as a whole. The gelatinized grains are as much swollen, have rather thin capsules, and are more distorted than in *L. martagon album.*

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in 92 per cent of the entire number of grains and 99 per cent of the total starch in 3 minutes, and in about 99 per cent of the grains and more than 99 per cent of the total starch in 5 minutes. (Chart D 348.)

The hilum becomes distinct in all the grains, attended by the formation of a bubble in a majority of grains—many more than in *L. martagon album.* The lamellæ are as distinct as in *L. martagon album.* Gelatinization begins at the hilum, which swells rapidly, more toward the proximal than toward the distal end. Two fissures extend obliquely from either side of the hilum three-fourths of the distance from the hilum to the distal margin. The starch included between them is fissured by finer, more numerous, and less distinct, furrows than in *L. martagon album.* As gelatinization progresses and the grain swells, these fissures separate the portion near the hilum into spicules which become more refractive and are gelatinized. The remaining starch forms a much smaller and more indistinctly granular mass at the distal end. The material at the proximal end and sides forms a homogeneous-looking, refractive band which is thinner at the proximal end than elsewhere. The capsule as in *L. martagon album* is first dissolved at the proximal end. Solution proceeds distally and the last part of the grain to be gelatinized is the capsule at the distal end. The granular mass at the distal end is often completely gelatinized before dissolution of the other parts occurs, differing in this from *L. martagon album.*

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 89 per cent of the entire number of grains and in more than 99 per cent of the total starch in 5 minutes. (Charts D 349 and D 351.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in more than 99 per cent of the entire number of grains and total starch in 15 seconds, and in 100 per cent of the grains and total starch in 30 seconds.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 89 per cent of the entire number of grains and 97 per cent of the total starch in 30 seconds; in more than 99 per cent of the grains and total starch in 1 minute; and in 100 per cent of the grains and total starch in 1 minute and 15 seconds.

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in 100 per cent of the entire number of grains and total starch in 15 seconds.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in 100 per cent of the grains and total starch in 10 seconds.

The hilum becomes distinct, attended by the formation of a bubble in the majority of the grains. The lamellæ are more distinct than in *L. martagon album.* Gelatinization begins at the hilum, which swells more rapidly in the direction of the proximal than the distal end. Two fissures extend from either side of the hilum three-fourths of the distance from the hilum to the distal margin. The material included between them is more distinctly, extensively, and irregularly fissured than in *L. martagon album.* This portion of the grain gelatinizes more rapidly than the similar part of *L. martagon album.* It leaves a small, definitely granular residue at the distal end which is more often gelatinized before the rest of the grain than in *L. martagon album.* The material at the proximal and distal margins and sides forms a homogeneous-looking refractive band which gradually grows thinner and more nearly transparent until it is all gelatinized. The gelatinized grains are more swollen, have thinner capsules, and are more distorted, particularly at the distal end, than in *L. martagon album.*

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in 100 per cent of the grains and total starch in 30 seconds.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 93 per cent of the entire number of grains and 99 per cent of the total starch in 15 seconds; in about 99 per cent of the grains and in more than 99 per cent of the total starch in 30 seconds; and in 100 per cent of the grains and total starch in 1 minute.

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in 100 per cent of the entire number of grains and total starch in 15 seconds.

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in all grains, 100 per cent of the entire number of grains and total starch in 10 seconds.

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 98 per cent of the grains and in more than 99 per cent of the total starch in 15 seconds, and in 100 per cent of the grains and total starch in 25 seconds.

The reaction with *sodium salicylate* begins in 30 seconds. Complete gelatinization occurs in about 53 per cent of the entire number of grains and 69 per cent of the total starch in 3 minutes; in about 95 per cent of the grains and 97 per cent of the total starch in 5 minutes; and in about 100 per cent of the grains and total starch in 10 minutes. (Chart D 352.)

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 73 per cent of the entire number of grains and 95 per cent of the total starch in 1 minute; and in about 98 per cent

of the grains and in more than 99 per cent of the total starch in 3 minutes.

The reaction with *uranium nitrate* begins in 15 seconds. Complete gelatinization occurs in about 77 per cent of the entire number of grains and 93 per cent of the total starch in 1 minute, and in 100 per cent of the grains and total starch in 3 minutes.

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 85 per cent of the entire number of grains and 95 per cent of the total starch in 1 minute, and in 100 per cent of the grains and total starch in 2 minutes.

The reaction with *cobalt nitrate* begins immediately. Complete gelatinization occurs in about 73 per cent of the entire number of grains and 95 per cent of the total starch in 1 minute, and in about 95 per cent of the grains and in more than 99 per cent of the total starch in 3 minutes.

The hilum is distinct in all the grains, accompanied by the formation of a bubble in many more than in *L. martagon album*. The lamellæ are not so distinct as in *L. martagon album*. Gelatinization begins at the hilum, which swells even more rapidly than in *L. martagon album*, unaccompanied by invagination of the proximal end. Two short fissures extend obliquely from either side toward the distal margin, and the material comprehended between them is divided by longitudinal and oblique fissures which are not so distinct or so long as in *L. martagon album*. As the grain swells it is quickly transformed into an irregularly granular mass, of which the granules are not so distinct or so refractive as in *L. martagon album*, and this is pushed to the distal margin where it is sometimes divided by wedge-shaped fissures into a serrated border, but not so frequently as in *L. martagon album*. In the other grains it forms merely an irregular granular mass at the distal margin that is sometimes entirely gelatinized before the material at the proximal end and sides. This, as the grain swells, forms a homogeneous-looking, refractive band which shows no lamellar markings as in *L. martagon album*. The gelatinized grains are as much swollen, have thinner capsules, and are usually not so much distorted at the distal end as in *L. martagon album*.

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 97 per cent of the entire number of grains and 99 per cent of the total starch in 1 minute, and in 100 per cent of the grains and total starch in 2 minutes.

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 84 per cent of the entire number of grains and 98 per cent of the total starch in 1 minute, and in 100 per cent of the grains and total starch in 3 minutes.

The hilum becomes distinct in all the grains, attended by the formation of a bubble in a moderate minority of the grains, instead of a majority as in *L. martagon album*. The lamellæ are somewhat more distinct than in *L. martagon album*. Gelatinization begins at the hilum, which swells more rapidly toward the proximal than the distal end. As the hilum and the grain enlarge there is a deep invagination of the proximal end which is later pushed out again. This feature is not seen in *L. martagon album*. Two fissures extend from the hilum one half to three-fourths of the distance from the hilum to the distal margin. The starch comprehended between them is more indistinctly fissured than in *L. martagon album* and is rapidly gelatinized, leaving a much smaller granular residue at the distal end than in *L. martagon album*. This is gelatinized before the deposit at the margin. The starch at the proximal and distal margin and sides, as in *L. martagon album*, forms a homogeneous-looking, refractive band which gradually grows thinner and more nearly transparent until it is completely gelatinized and only the capsule remains. The gelatinized grains are as much swollen as in *L. martagon album*. They have less thick capsules, and are more distorted at the distal end, than in *L. martagon album*.

The reaction of *barium chloride* begins immediately. Complete gelatinization occurs in about 68 per cent of the entire number of grains and 89 per cent of the total starch in 1 minute; in about 89 per cent of the grains and 97 per cent of the total starch in 3 minutes; and in about 95 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 353.)

The reaction with *mercuric chloride* begins immediately. Complete gelatinization occurs in about 83 per cent of the entire number of grains and 97 per cent of the total starch in 30 seconds; and in about 96 per cent of the grains and in more than 99 per cent of the total starch in 1 minute.

Lilium marhan (Hybrid).

(Plate 15, fig. 90; Charts D 347 to D 353.)

Histologic Properties.

In *form* the grains are usually simple and isolated. Compound grains are as rare as in *L. maculatum*, and are of the type described under both parents. The grains are more often irregular than in either parent, in this respect more closely resembling *L. maculatum*, and the irregularities are due to the same causes, secondary sets of lamellæ being more common than in that starch. The conspicuous forms are broad and narrow pyriform, broad and narrow triangular with curved base and rounded angles, elongated ovoid with squared or rounded distal end, and clam-shell-shaped. The additional forms are club-shaped, finger-shaped, nearly round, oyster-shell-shaped, and dome-shaped. As in both parents, the broad forms are somewhat flattened, and when viewed on edge have an elongated ovoid shape.

In form *L. marhan* shows a closer relationship to *L. maculatum* than to *L. martagon album*.

The *hilum* is as distinct as in *L. martagon album* and less distinct than in *L. maculatum*, and is more often fissured or occupied by a cavity than in either parent, in the first characteristic more closely resembling *L. maculatum* and in the second *L. martagon album*. The fissures have the same form as in *L. martagon album*. The hilum is eccentric from 0.32 to 0.1, usually 0.2, of the longitudinal axis, slightly more than in *L. martagon album*, but less than in *L. maculatum*.

In the character and eccentricity of the hilum *L. marhan* shows, on the whole, a closer relationship to *L. martagon album* than to *L. maculatum*.

The *lamellæ* are as distinct and as fine as in *L. martagon album*, and have otherwise the same characteristics and arrangement as in both parents. The number

counted on the larger grains varies from 30 to 52, usually 40, which is intermediate between the numbers of the parents.

In the character and arrangement of the lamellæ, *L. marhan* shows for the most part a closer relationship to *L. martagon album* than to *L. maculatum.*

In *size* the grains vary from the smaller which are 5 by 4μ, to the larger elongated forms which are 50 by 40μ, and the larger broad forms which are 34 by 48μ, in length and breadth. The common sizes are 28 by 24μ and 28 by 18μ in length and breadth.

In size *L. marhan* shows a closer relationship to *L. maculatum* than to *L. martagon album.*

Polariscopic Properties.

The *figure* is as distinct and as well defined as in *L. maculatum,* but not so well defined as in *L. martagon album.* The lines as in *L. maculatum* intersect at a very acute angle, which does not vary much in size in the different grains. They are more frequently bent and bisected than in either of the parents, which are alike in this characteristic.

The *degree of polarization* varies from low to high (value 50), the same as in *L. maculatum* and lower than in *L. martagon album.* There is often considerable variation in a given aspect of an individual grain.

With *selenite* the quadrants are as clean-cut as in *L. maculatum.* They are as unequal in size and more irregular in shape than in that starch. The colors are usually not pure as in *L. maculatum.*

In the degree of polarization, the character of the figure, and the appearance with selenite, *L. marhan* shows a closer relationship to *L. maculatum* than to *L. martagon album.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate blue-violet (value 58), somewhat more than in *L. maculatum* and much less than in *L. martagon album.* With 0.125 per cent Lugol's solution the grains all color a light blue-violet, somewhat more than in *L. maculatum* but less than in *L. martagon album.* After heating in water until all the grains are completely gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* all color a light or occasionally a moderate indigo-blue, somewhat more than in *L. maculatum* and considerably less than in *L. martagon album.* The *solution* colors a deep indigo, as in *L. maculatum.* If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, some of the *grain-residues* color a very light indigo, but in most of them only the capsule is colored as in *L. maculatum;* the *capsules* color reddish violet, and the *solution* a very deep indigo.

Qualitatively and quantitatively the reaction with iodine shows a closer relationship to *L. maculatum* than to *L. martagon album.*

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes most of them are lightly or moderately and a few are moderately to deeply colored (value 43), somewhat less than in *L. maculatum* and very much less than in *L. martagon album.* As in the parents, the distal end of the grain is more colored than the proximal end.

With *safranin* the grains all color very lightly at once, and in 30 minutes most of them are lightly or moderately and a few moderately to deeply colored (value 43), somewhat less than in *L. maculatum* and very much less than in *L. martagon album.* As in both parents, the distal is more colored than the proximal end. In the reactions with aniline stains *L. marhan* shows a closer relationship to *L. maculatum* than to *L. martagon album.*

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 56° to 58° C., and of all is 59° to 60° C., the mean is 59.5° C. The temperature of gelatinization of *L. marhan* is lower than that of both parents, but is closer to *L. maculatum* than to *L. martagon album.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 30 seconds. Complete gelatinization occurs in about 26 per cent of the entire number of grains and 65 per cent of the total starch in 5 minutes; in about 80 per cent of the grains and 95 per cent of the total starch in 15 minutes; and in about 96 per cent of the grains and 98 per cent of the total starch in 30 minutes. (Chart D 347.)

The hilum, as in *L. maculatum,* becomes distinct, attended by the formation of a bubble in a large minority of the grains. The lamellæ are not visible, as in both parents. Gelatinization begins at the corners of the distal margin, and then immediately at the proximal end, as in *L. martagon album* and in some grains of *L. maculatum.* It progresses smoothly, as in *L. martagon album,* and the last part of the grain to be gelatinized is just distal to the hilum. This is, however, not always split into two portions as in *L. martagon album,* but in some grains gelatinized as a whole, as in *L. maculatum.* The gelatinized grains are as much swollen, have as thick capsules, and are as much distorted as in *L. martagon album.* In this reaction *L. marhan* shows qualitatively a closer relationship to *L. martagon album* than to *L. maculatum.*

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 82 per cent of the entire number of grains and 99 per cent of the total starch in 3 minutes, and in about 98 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 348.)

The hilum becomes distinct in all the grains, attended by the formation of a bubble in but few grains. The lamellæ are as distinct as in both parents. Gelatinization begins at the hilum and progresses as in *L. maculatum,* differing from *L. martagon album* in the same ways as does that starch from *L. maculatum.*

In this reaction *L. marhan* shows qualitatively a somewhat closer relationship to *L. maculatum* than to *L. martagon album.*

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 90 per cent of the grains and 99 per cent of the total starch in 5 minutes. (Chart D 349.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in more than 99 per cent of the entire number of grains and total starch in 15 seconds and in 100 per cent of the grains and total starch in 30 seconds.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 85 per cent of

the entire number of grains and 93 per cent of the total starch in 30 seconds; in about 99 per cent of the grains and in more than 99 per cent of the total starch in 1 minute; and in 100 per cent of the grains and total starch in 1 minute and 30 seconds.

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in 100 per cent of the grains and total starch in 15 seconds.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in 100 per cent of the entire number of grains and total starch in 10 seconds.

The hilum becomes distinct in all the grains, attended by the formation of a bubble in a moderate minority, fewer than in *L. maculatum.* The lamellæ are as distinct as in *L. martagon album* and less distinct than in *L. maculatum.* Gelatinization begins at the hilum and progresses as in *L. maculatum,* except that fissuring is not so extensive or so irregular, and the granules comprising the residue at the distal end are not so refractive nor so distinct, as in *L. maculatum,* showing the influence of *L. martagon album.* The gelatinized grains are as much swollen and have as thin capsules as in *L. martagon album,* but are as much distorted as in *L. maculatum.* In this reaction *L. marhan* shows qualitatively a closer relationship to *L. maculatum* than to *L. martagon album.*

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in 100 per cent of the grains and total starch in 30 seconds.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 94 per cent of the entire number of grains and 98 per cent of the total starch in 15 seconds; in more than 99 per cent of the grains and total starch in 30 seconds, and in 100 per cent of the grains and total starch in 1 minute.

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in 100 per cent of the entire number of grains and total starch in 15 seconds.

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in all the grains in 12 seconds.

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 92 per cent of the entire number of grains and 98 per cent of the total starch in 15 seconds; in about 98 per cent of the grains and in more than 99 per cent of the total starch in 30 seconds; and in more than 99 per cent of the grains and total starch in 45 seconds. Very rare resistant grains remain ungelatinized for 5 minutes or longer—not so many as in *L. martagon album,* but more than in *L. maculatum,* since such grains were not observed in the latter species.

The reaction with *sodium salicylate* begins in 30 seconds. Complete gelatinization occurs in about 20 per cent of the entire number of grains and 32 per cent of the total starch in 3 minutes; in about 72 per cent of the grains and 90 per cent of the total starch in 5 minutes; and in about 99 per cent of the grains and in more than 99 per cent of the total starch in 10 minutes. (Chart D 352.)

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 75 per cent of the entire number of grains and 91 per cent of the total starch in 1 minute, and in more than 99 per cent of the grains and total starch in 3 minutes.

The reaction with *uranium nitrate* begins in 15 seconds. Complete gelatinization occurs in about 72 per cent of the entire number of grains and 89 per cent of the total starch in 1 minute, and in more than 99 per cent of the grains and total starch in 3 minutes.

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 70 per cent of the entire number of grains and 81 per cent of the total starch in 1 minute, and in more than 99 per cent of the grains and total starch in 3 minutes.

The reaction with *cobalt nitrate* begins immediately. Complete gelatinization occurs in about 66 per cent of the entire number of grains and 83 per cent of the total starch in 1 minute, and in about 97 per cent of the grains and in more than 99 per cent of the total starch in 3 minutes.

The hilum becomes distinct in all of the grains, accompanied by the formation of a bubble in as many as in *L. maculatum.* The lamellæ are as distinct as in *L. martagon album.* Gelatinization begins at the hilum and progresses as in *L. maculatum,* except that the fissures in the distal material are even less distinct and the granules less distinct and less refractive than in that grain. Invagination of the proximal end when the hilum first swells is often seen as in *L. martagon album.* The gelatinized grains are as much swollen as in both parents. They have as thin capsules as in *L. maculatum* and are usually more distorted than in *L. maculatum* and less than in *L. martagon album.*

In this reaction *L. marhan* shows qualitatively a somewhat closer relationship to *L. maculatum* than to *L. martagon album.*

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 93 per cent of the entire number of grains and 98 per cent of the total starch in 1 minute, and in more than 99 per cent of the grains and total starch in 2 minutes, and about the same in 3 minutes.

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 77 per cent of the grains and 97 per cent of the total starch in 1 minute, and in more than 99 per cent of the grains and total starch in 3 minutes.

The hilum becomes distinct in all the grains, attended by the formation of a bubble in as many grains as in *L. maculatum.* The lamellæ are as distinct as in *L. martagon album.* Gelatinization begins at the hilum and progresses as in *L. maculatum* in the great majority of the grains; but in a few grains exactly as in *L. martagon album.* The gelatinized grains are as much swollen as in both parents. They have as thin capsules and are as much distorted as in *L. maculatum.*

In this reaction *L. marhan* shows qualitatively a somewhat closer relationship to *L. maculatum* than to *L. martagon album.*

The reaction with *barium chloride* begins immediately. Complete gelatinization occurs in about 43 per cent of the entire number of grains and 82 per cent of the total starch in 1 minute; in about 94 per cent of the grains and 99 per cent of the total starch in 3 minutes;

and in about 98 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 353.)

The reaction with *mercuric chloride* begins immediately. Complete gelatinization occurs in about 82 per cent of the entire number of grains and 94 per cent of the total starch in 30 seconds, and in about 98 per cent of the grains and in more than 99 per cent of the total starch in 1 minute.

26. Starches of Lilium martagon, L. maculatum, and L. dalhansoni.

Starch of *Lilium maculatum* (pollen parent) is described on pages 601 to 603.

Lilium martagon (Seed Parent).

(Plate 16, fig. 91; Charts D 354 to D 360.)

Histologic Properties.

In *form* the grains are usually simple and isolated. A very few compound grains are seen and no aggregates. The compound grains all belong to one type: 2 small grains, each consisting of a hilum and 2 or 3 lamellæ, become adherent and are surrounded by 20 to 40 common secondary lamellæ so that they lie at the proximal end of a large grain. The smaller grains and the majority of the common-sized grains are regular, and the larger grains often somewhat irregular, in form. The irregularities are due to the following causes: (1) Small irregular elevations and depressions of the distal surface and margin, associated with which there is often a narrow, rather shallow notch in the center of the distal margin; (2) a shifting of the longitudinal axis of the grain, with a resulting curvature in the middle or at the distal end of the grain; (3) a large rounded or pointed protuberance from the side, or the distal or proximal end; (4) a secondary set of lamellæ whose longitudinal axis is placed at an angle varying from 90° to 40° with the axis of the primary grain. The conspicuous forms are elongated ovoid with flattened distal end, broad pyriform, and lenticular with sharp or blunt ends. The additional forms are almost round, oyster-shell-shaped, narrow pyriform, irregularly quadrilateral and triangular, and club-shaped. The grains are not flattened, but some of the broad triangular and quadrilateral forms when seen on edge have an elongated ovoid shape.

The *hilum* is a moderately distinct, round, rarely lenticular-shaped spot. It is usually not fissured, and when it is fissured the fissures are not deep or extensive. They have the following forms: (1) A small, straight, transverse line; (2) an irregularly stellate arrangement of a number of short fissures. The hilum is eccentric from 0.26 to 0.06, usually 0.11, of the longitudinal axis.

The *lamellæ* are usually fine and moderately distinct. Those around the hilum are continuous and oval or round in shape. The remaining lamellæ have the form of the outline of the grain and appear to be incomplete. There is usually one broad refractive lamella located at about one-half to two-thirds of the distance from the hilum to the distal margin which separates the fine and moderately distinct lamellæ of the proximal part of the grain from the less fine and more distinct lamellæ of the distal portion. In a moderate number of grains there are 4 or 5 broad highly refractive lamellæ which separate the fine lamellæ into bands of varying breadth. The number of lamellæ counted on the larger grains varies from 20 to 50, usually 30.

In *size* the grains vary from the smaller which are 7 by 6μ, to the larger which are 50 by 36μ and, rarely, 55 by 55μ, in length and breadth. The common sizes are 30 by 15μ and 30 by 24μ.

Comparison of the *histologic properties* between *L. maculatum* and *L. martagon* shows:

Form: There are very few compound grains and no aggregates, and the compound grains are of the same type as in *L. martagon.* The grains are more regular than in *L. martagon,* but the irregularities which do occur are due to the same causes as in that starch, to which may be added the greater development of one part of the distal end than the rest. Broad forms are more numerous than in *L. martagon,* and therefore more grains are somewhat flattened. When viewed on edge these grains have a regular ovoid form as in *L. martagon.*

The *hilum* is more distinct than in *L. martagon* and much more often fissured. The fissures have the following forms: (1) A refractive cavity from either side of which 2 delicate fissures extend obliquely toward the distal end; (2) a single, short, straight, transverse line. The hilum is somewhat less eccentric than in *L. martagon,* usually 0.15, of the longitudinal axis.

The *lamellæ* are less fine, more distinct, and less numerous than in *L. martagon,* but are otherwise the same in character and arrangement as those of that starch.

In *size* the grains are about the same, but usually somewhat broader than those of *L. martagon,* the common sizes are 30 by 24μ and 28 by 20μ in length and breadth.

Polariscopic Properties.

The *figure* is distinct and usually well defined. The lines cross at a very acute angle which does not vary much in size in the different grains. They are often very much bent, but are rarely if ever bisected.

The *degree of polarization* varies from low to high (value 60). There are very few grains in which it is low and many in which it is moderate or high. There is rarely any variation in a given aspect of an individual grain.

With *selenite* the quadrants are well defined, very unequal in size, and often irregular in shape. The colors are usually pure, the blue more often than the yellow. In the small grains they are not pure.

Comparison of the *polariscopic properties* between *L. maculatum* and *L. martagon* shows:

The *figure* is as distinct, but is not so well defined, as in *L. martagon.* The lines cross at less of an acute angle, and are somewhat less often bent, than in *L. martagon.*

The *degree of polarization* varies from low to high (value 50), less than in *L. martagon,* as it is high in fewer grains and moderate in more grains than in that starch. There is rarely any variation in a given aspect of an individual grain.

With *selenite* the quadrants are not so well defined, less unequal in size, and not so irregular in shape, as in *L. martagon.* The colors also are less often pure.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate to deep blue-violet (value 60). The

color deepens very rapidly until very deep and much more bluish. With 0.125 per cent Lugol's solution the grains all color a light to moderate blue-violet, which deepens rapidly until very deep and much more bluish. After heating in water until the grains are all completely gelatinized and then treating with a 2 per cent Lugol's solution, most of the gelatinized *grains* color a light indigo, while in some only the capsule is colored a reddish violet, and the *solution* colors a deep indigo. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, most of the *grain-residues* are not colored, but a few are colored a very light or a light indigo, the *capsules* a reddish violet or violet, and the *solution* a very deep indigo.

Comparison of the *iodine reactions* between *L. maculatum* and *L. martagon* shows:

With 0.25 per cent Lugol's solution the grains color somewhat less than in *L. martagon* (value 55), and so also with an 0.125 per cent Lugol's solution. After heating in water until the *grains* are all gelatinized, many are colored less and more not colored at all than in *L. martagon;* the *solution* is more deeply colored. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, not so many of the *grain-residues* are colored a very light indigo as in *L. martagon,* the *capsules* are colored reddish violet and violet, and the *solution* a very deep indigo, as in *L. martagon.*

Aniline Reactions.

With *gentian violet* the grains all color, very lightly at once, and in 30 minutes they are colored moderately or moderately to deeply (value 55). Most of the grains are moderately and a very few moderately to deeply colored. The individual grains are usually colored more at the distal end than elsewhere.

With *safranin* the grains all color, very lightly at once, and in 30 minutes the great majority are moderately and a few moderately to deeply colored (value 55), the same as with gentian violet. The individual grains are usually colored more at the distal end than elsewhere.

Comparison of the *aniline reactions* between *L. maculatum* and *L. martagon* shows:

With *gentian violet* most of the grains are lightly to moderately colored and a few moderately to deeply colored (value 45), less than in *L. martagon.* There is the same unevenness of coloring in the individual grains as in that starch.

With *safranin* the grains are light to moderate or moderate to deeply colored (value 45), less than in *L. martagon.* There is the same unevenness of coloring in the individual grains as in that starch.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 62° to 64° C., and of all is 66.5° to 68.3° C., mean 67.4° C.

Comparison of the *temperature reactions* between *L. maculatum* and *L. martagon* shows:

The temperature of gelatinization is less than that of *L. martagon,* 60° to 62° C., mean 61° C., a difference of 6.4° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 30 seconds. Complete gelatinization occurs in about 24 per cent of the entire number of grains and 69 per cent of the total starch in 5 minutes; in about 80 per cent of the grains and 95 per cent of the total starch in 15 minutes; and in about 95 per cent of the grains and 99 per cent of the total starch in 30 minutes. (Chart D 354.)

The hilum becomes distinct, attended by the formation of a bubble in but few grains. The lamellæ are not visible. The grains become more refractive after the addition of the reagent, and the first part of the grain to show this change is a rather broad strip of starch at the margin which becomes very refractive. Gelatinization begins at the distal margin and progresses half the distance from the hilum to the margin before the proximal end is gelatinized. Gelatinization progresses smoothly, preceded by small hollows in the margin and pitting of the surface of the ungelatinized portion of the grain. It proceeds more rapidly along the sides than in the central part of the grain, so that the ungelatinized starch has the shape of an inverted cone. The last portion of the grain to be gelatinized is just distal to the hilum, and this is split into two pieces which gelatinize independently in about half of the grains; in the other half it is gelatinized as one piece. The gelatinized grains are much swollen, have rather thick capsules, and are greatly distorted. They do not retain any resemblance to the form of the untreated grain.

Comparison of the *chloral-hydrate* reactions between *L. maculatum* and *L. martagon* shows:

A bubble is formed at the hilum in more grains than in *L. martagon,* and the lamellæ, as in *L. martagon,* are not visible. Gelatinization begins at the distal margin and in many grains immediately afterwards at the distal end, but in some, as in *L. martagon,* not until the distal half is gelatinized. It progresses by the invasion of the ungelatinized starch by fissures, at which points the material is gelatinized and great hollows are made in the ungelatinized portion. There are no shallow depressions on the margin and no pitting of the surface as in *L. martagon.* The last part of the grain to be gelatinized is, as in *L. martagon,* that just distal to the hilum, and this is never split into two pieces, as in some grains of *L. martagon,* but is gelatinized in one piece, as in the majority of the grains of *L. martagon.* The gelatinized grains are as much swollen, but have rather thin capsules instead of thick capsules as in *L. martagon.* They are as much distorted as in that starch and do not retain any resemblance to the form of the untreated grain.

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 14 per cent of the grains and 65 per cent of the total starch in 3 minutes; in about 55 per cent of the grains and 82 per cent of the total starch in 5 minutes; in about 67 per cent of the grains and 89 per cent of the total starch in 15 minutes; and in about 97 per cent of the grains and in more than 99 per cent of the total starch in 30 minutes. (Chart D 355.)

The hilum becomes distinct in all the grains, attended by the formation of a bubble in but few of them. The lamellæ are distinct. Gelatinization begins at the hilum, which swells more rapidly toward the proximal than toward the distal end. The short fissures extend from either side of the hilum not more than half of the distance from the hilum to the distal margin, and the starch included between them is distinctly and irregularly fis-

sured. The portion just distal to the hilum is divided into spicules by a double row of short fissures which slant proximally. These spicules are gelatinized, leaving a residue of refractive granules. The remainder of the starch is distinctly and irregularly fissured, and as gelatinization proceeds forms an irregularly granular mass at the distal end of the grain. The deposit at the proximal end and sides forms a homogeneous-looking, refractive band which is thinner at the proximal end than elsewhere. The capsule is first dissolved at this point and continues toward the distal end. The last part of the grain to be gelatinized is the distal margin, and the granular starch at the distal end is the next to the last.

Comparison of the *chromic-acid* reactions between *L. maculatum* and *L. martagon* shows:

A bubble is formed in a majority of the grains instead of in a few grains as in *L. martagon*. The lamellæ are as distinct as in this starch. Gelatinization progresses in a similar manner, the main differences noted being that the starch distal to the hilum is divided by much finer, more numerous, and less distinct fissures than in *L. martagon,* and there is no division by a double row of slanting fissures as in that grain. The material formed from this part of the grain is much less in amount, much less distinctly granular, and more easily gelatinized than similar material in *L. martagon.* Otherwise the reactions are the same.

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 30 per cent of the entire number of grains and 77 per cent of the total starch in 5 minutes; in about 41 per cent of the grains and 89 per cent of the total starch in 15 minutes; in about 61 per cent of the grains and 91 per cent of the total starch in 30 minutes; in about 66 per cent of the grains and 95 per cent of the total starch in 45 minutes; and in about 67 per cent of the grains and 96 per cent of the total starch in 60 minutes. (Charts D 356 and D 357.) A small area at the distal margin of a number of the grains is very resistant.

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 93 per cent of the entire number of grains and 97 per cent of the total starch in 15 seconds; in about 99 per cent of the grains and total starch in 30 seconds; and in more than 99 per cent of the grains and total starch in 45 seconds. The rare scattered grains remaining ungelatinized in 45 seconds may resist gelatinization for 5 minutes and longer.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 93 per cent of the entire number of grains and 97 per cent of the total starch in 30 seconds, and in about 99 per cent of the grains and in more than 99 per cent of the total starch in 1 minute. Very rare grains remain ungelatinized for 5 minutes or longer.

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 94 per cent of the entire number of grains and 97 per cent of the total starch in 15 seconds, and in more than 99 per cent of the grains and total starch in 30 seconds. The rare scattered ungelatinized grains may resist the reaction for 5 minutes or longer.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in more than 99 per cent of the entire number of grains and total starch in 15 seconds.

The hilum becomes distinct in all the grains, unattended by the formation of a bubble in any grain. The lamellæ are distinct. Gelatinization begins at the hilum, which swells more rapidly toward the proximal than toward the distal end of the grain. Two fissures which are continued as furrows extend from either side of the hilum three-quarters of the distance from the hilum to the distal margin. The starch that is included between them is fissured very indistinctly. As the grain swells this material grows less and less in amount and the fissures become somewhat more distinct. Near the end of the reaction it is all gelatinized but a small, irregular refractive mass at the distal end, which slowly gelatinizes, with considerable infolding and other distortion of the capsule at this point. In the majority of the grains this is the last part to be gelatinized. The starch at the proximal and the distal margin and sides forms a thick, homogeneous-looking, refractive band, which grows thinner and more nearly transparent until it is completely gelatinized and only the capsule remains. The gelatinized grains are much swollen, have rather thin capsules, and are considerably distorted, particularly at the distal end.

Comparison of the *potassium-hydroxide* reactions between *L. maculatum* and *L. martagon* shows:

A bubble is formed in the majority of the grains. This does not occur at all in *L. martagon.* The lamellæ are more distinct than in the latter. Gelatinization proceeds in much the same way as in *L. martagon,* except that the starch that is included between the two fissures which proceed from the hilum is much more extensively, irregularly, and distinctly fissured, and is much more rapidly gelatinized, than a similar part of the grain in *L. martagon.* It leaves a small, definitely granular residue at the distal end which is usually gelatinized before instead of after the rest of the grain. The gelatinized grains are more swollen, have thinner capsules, and are more distorted, particularly at the distal end, than in *L. martagon.*

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 60 per cent of the entire number of grains and 84 per cent of the total starch in 30 seconds; in about 72 per cent of the grains and 94 per cent of the total starch in 1 minute; in about 88 per cent of the grains and 98 per cent of the total starch in 3 minutes; and in about 96 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 55 per cent of the entire number of grains and 86 per cent of the total starch in 15 seconds; in about 81 per cent of the grains and 95 per cent of the total starch in 30 seconds; in about 86 per cent of the grains and 98 per cent of the total starch in 1 minute; and in about 95 per cent of the grains and 99 per cent of the total starch in 3 minutes. Scattered grains remain ungelatinized for 5 minutes or longer.

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 88 per cent of the entire number of grains and 95 per cent of the total starch in 15 seconds, and in more than 99 per cent

of the grains and total starch in 25 seconds. Rare grains are resistant for 5 minutes.

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 84 per cent of the grains and 92 per cent of the total starch in 15 seconds; in about 92 per cent of the grains and 97 per cent of the total starch in 30 seconds; and in about 97 per cent of the grains and 99 per cent of the total starch in 60 seconds. Resistant grains remain ungelatinized for 5 minutes and longer.

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 70 per cent of the entire number of grains and 90 per cent of the total starch in 15 seconds; in about 94 per cent of the grains and 98 per cent of the total starch in 30 seconds; and in more than 99 per cent in 45 seconds. Rare resistant grains remain ungelatinized for 5 minutes or longer.

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 43 per cent of the entire number of grains and 60 per cent of the total starch in 3 minutes; in about 67 per cent of the grains and 84 per cent of the total starch in 5 minutes; and in about 95 per cent of the grains and 98 per cent of the total starch in 10 minutes. (Chart D 358.)

The reaction with *calcium nitrate* begins in a few grains in 15 seconds. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 10 per cent of the total starch in 1 minute; in about 51 per cent of the grains and 90 per cent of the total starch in 3 minutes; in about 68 per cent of the grains and 97 per cent of the total starch in 5 minutes; and in about 79 per cent of the grains and 99 per cent of the total starch in 10 minutes. A small area at the distal margin is very resistant in a number of grains.

The reaction with *uranium nitrate* begins in 30 seconds. Complete gelatinization occurs in about 50 per cent of the entire number of grains and 60 per cent of the total starch in 1 minute; in about 89 per cent of the grains and 97 per cent of the total starch in 3 minutes; and in about 93 per cent of the grains and 99 per cent of the total starch in 5 minutes.

The reaction with *strontium nitrate* begins in 15 seconds. Complete gelatinization occurs in about 57 per cent of the entire number of grains and 77 per cent of the total starch in 1 minute; and in about 95 per cent of the grains and in more than 99 per cent of the total starch in 3 minutes.

The reaction with *cobalt nitrate* begins immediately. Complete gelatinization occurs in 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 1 minute; in about 33 per cent of the grains and 66 per cent of the total starch in 3 minutes; in about 44 per cent of the grains and 84 per cent of the total starch in 5 minutes; and in about 78 per cent of the grains and 95 per cent of the total starch in 15 minutes. (Chart D 359.)

The hilum becomes distinct in all the grains, attended by the formation of a bubble in a moderate number. The lamellæ are distinct. Gelatinization begins at the hilum, which enlarges rapidly, especially toward the proximal end. Two fissures extend obliquely from either side of the hilum nearly to the distal margin and the starch included between them is first divided by fine longitudinal and oblique fissures which, as the grain swells, separate it into spicules. As the grain continues to swell this portion is pushed to the distal end and it, together with the deposit at the distal margin, is divided by wedge-shaped fissures into a serrated border. Meanwhile, the part at the proximal end and sides forms a refractive marginal band which shows 2 or 3 faint lamellar markings. It gradually loses this lamellated appearance and becomes thinner and more nearly transparent until it is completely gelatinized and only the capsule is left. The granular starch at the distal end gradually grows more nearly transparent and is finally gelatinized, with considerable distortion and infolding of the capsule at this point. The gelatinized grains are much swollen, have rather thin capsules, and are very much distorted at the distal end and very little distorted at the proximal end.

Comparison of the *cobalt-nitrate* reactions between *L. maculatum* and *L. martagon* shows:

A bubble is formed at the hilum in many more grains than in *L. martagon,* and the lamellæ are not so distinct as in that starch. The fissures extending from either side of the hilum are shorter and the starch included between them is divided by longitudinal and oblique fissures which are not so distinct nor so long as in *L. martagon.* It is more quickly gelatinized and is less definitely granular than in *L. martagon* and is less frequently divided into a serrated inner border than in that starch. The marginal band at the proximal end and sides nearby is homogeneous-looking, and not lamellated, and is more refractive than in *L. martagon.* The gelatinized grains are as much swollen, have thinner capsules, and are usually not so distorted at the distal end as in *L. martagon.*

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 42 per cent of the entire number of grains and 69 per cent of the total starch in 1 minute; in about 84 per cent of the grains and 98 per cent of the total starch in 3 minutes; and in about 95 per cent of the grains and 99 per cent of the total starch in 5 minutes.

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 33 per cent of the entire number of grains and 60 per cent of the total starch in 1 minute; in about 80 per cent of the grains and 95 per cent of the total starch in 3 minutes; in about 88 per cent of the grains and 96 per cent of the total starch in 5 minutes; and in about 95 per cent of the grains and 99 per cent of the total starch in 15 minutes.

The hilum becomes distinct in all the grains, attended by the formation of a bubble in rare grains. The lamellæ become distinct. Gelatinization begins at the hilum, which swells more rapidly toward the proximal than toward the distal end. Two fissures extend obliquely from either side of the hilum about one-half to three-quarters of the distance between the hilum and the distal margin. The material included between these two fissures is divided by distinct branching fissures, except the portion just distal to the hilum, which is divided into spicules or bundles of spicules by a double row of fissures which slant proximally from 2 original fissures on either side to the longitudinal axis of the grain. These spicules are gelatinized first and have a residue of scattered refractive granules. The remainder of the fissured portion is partially gelatinized, and as the grain swells the rest

of this portion forms a small, irregularly granular residue at the distal end of the grain. This is usually gelatinized before the marginal portion of the grain. The material at the proximal and distal margins and sides forms a refractive, homogeneous-looking band which is rather thick at first and gradually grows thinner and more nearly transparent until it is completely gelatinized, leaving only the capsule. The gelatinized grains are very much swollen, have rather thick capsules, and are somewhat distorted, particularly at the distal end.

Comparison of the *cupric-chloride* reactions between *L. maculatum* and *L. martagon* shows:

A bubble is formed at the hilum in more grains. The lamellæ are more distinct than in *L. martagon*. Gelatinization is somewhat different from the process described under *L. martagon*. As the hilum and grain swells there is an invagination at the proximal end which persists for some time, but is finally pushed out. This peculiarity is not seen in *L. martagon*. There is no division of the portion of the grain just distal to the hilum. The material included between the 2 fissures which extend from either side of the hilum is much more indistinctly fissured, and the granular residue left after this part of the grain has gelatinized is smaller and composed of less refractive granules than in *L. martagon*. The gelatinized grains are as much swollen, have less capsules, and are more distorted than in *L. martagon*.

The reaction with *barium chloride* begins in a few grains in 30 seconds. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 1 minute; in about 16 per cent of the grains and 52 per cent of the total starch in 3 minutes; in about 31 per cent of the grains and 76 per cent of the total starch in 5 minutes; in about 50 per cent of the grains and 86 per cent of the total starch in 15 minutes; in about 68 per cent of the grains and 89 per cent of the total starch in 30 minutes; in about 69 per cent of the grains and 90 per cent of the total starch in 45 minutes; and about the same in 60 minutes. (Chart D 360.)

The reaction with *mercuric chloride* begins in a few grains immediately. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 8 per cent of the total starch in 30 seconds; in about 48 per cent of the grains and 80 per cent of the total starch in 1 minute; in about 76 per cent of the grains and 97 per cent of the total starch in 3 minutes; and in about 86 per cent of the grains and 98 per cent of the total starch in 5 minutes.

Lilium dalhansoni (Hybrid).

(Plate 16, fig. 93; Charts D 354 to D 360.)

Histologic Properties.

The grains are simple and isolated and no compound grains, such as were seen in both parents, are observed. The grains are more regular than in either parent, in this respect more closely resembling *L. maculatum*. When irregularities are present they are due to the same causes as in *L. martagon*. The conspicuous forms are: Elongated ovoid with a flattened distal end, pure ovoid, and ellipsoidal. The additional forms are narrow pyriform, broad pyriform, nearly round, clam-shell-shaped, club-shaped, and oyster-shell-shaped. The grains are usually not flattened, except the broad forms, and these when seen on edge have an ovoid form, as in both parents. In form *L. dalhansoni* shows a somewhat closer relationship to *L. martagon* than to *L. maculatum*.

The *hilum* is as distinct as in *L. martagon* and is more often fissured than in that starch, but not quite so often as in *L. maculatum*. The fissures when present have the forms described in *L. maculatum*. The hilum is eccentric from 0.4 to 0.1, usually 0.18, of the longitudinal axis. In the character and the eccentricity of the hilum *L. dalhansoni* shows a somewhat closer relationship to *L. maculatum* than to *L. martagon*.

The *lamellæ* are as distinct and as fine as in *L. martagon*, but in character and arrangement are the same as in both parents. The number counted on the larger grains varies from 50 to 22, usually 38, about the same as in *L. maculatum* and in excess of *L. martagon*.

In the character and arrangement of the lamellæ *L. dalhansoni* shows a somewhat closer relationship to *L. martagon* than to *L. maculatum*, but in number closer to the latter.

In *size* the grains vary from the smaller which are 6 by 5μ, to the larger which are 40 by 26μ, rarely 50 by 30μ, in length and breadth. The common sizes are 30 by 18μ and 30 by 24μ.

In size the large grains of *L. dalhansoni* are not so large as in either parent, which are closely alike, but the dimensions of these and also of the common sizes are slightly closer to *L. martagon* than to *L. maculatum*.

Polariscopic Properties.

The *figure* is as distinct and as well defined as in *L. martagon*. The lines cross at somewhat less of an acute angle, and are not quite so often nor so much bent, as in *L. martagon*, but more often than in *L. maculatum*.

The *degree of polarization* varies from low to high (value 60), the same as in *L. martagon*. There are, as in that starch, very few grains in which it is low and many in which it is moderate or high. There is very little variation in a given aspect of an individual grain.

With *selenite* the quadrants are as well defined, but somewhat less unequal in size and irregular in shape, than in *L. martagon*. The colors are usually pure, as in that starch.

In the degree of polarization, the character of the figure, and the appearances with selenite *L. dalhansoni* shows a closer relationship to *L. martagon* than to *L. maculatum*.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate to deep blue-violet (value 65), more than in either parent but closer to *L. martagon*. With 0.125 per cent Lugol's solution the grains all color a light to moderate blue-violet, more than in either parent, but closer to *L. martagon*. After heating in water until the grains are all gelatinized and then treating with a 2 per cent Lugol's solution, most of the gelatinized grains color a light indigo, while in some only the *capsule* colors a reddish violet, and the *solution* colors a deep indigo, as in *L. martagon*. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, most of the *grain-residues* are not colored, but a few are colored a very light or a light indigo, the *capsules* a reddish violet or a violet, and the *solution* a very deep indigo, as in *L. martagon*.

Qualitatively and quantitatively the reaction with iodine shows a closer relationship to *L. martagon* than to *L. maculatum*.

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes most of them are moderately and a few moderately to deeply colored (value 55), the same as in *L. martagon* and more than in *L. maculatum*.

With *safranin* the grains all color very lightly at once, and in 30 minutes most of them are moderately and a few moderately to deeply colored (value 55), the same as in *L. martagon* and more than in *L. maculatum*.

In the reaction with aniline stains *L. dalhansoni* shows a closer relationship to *L. martagon* than to *L. maculatum*.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 59° to 60.2° C., and of all is 63° to 64.5° C., mean 63.9° C. The temperature of gelatinization of *L. dalhansoni* is somewhat closer to that of *L. maculatum* than to *L. martagon*, and nearly exactly midway between the two.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 30 seconds. Complete gelatinization occurs in about 36 per cent of the entire number of grains and 80 per cent of the total starch in 5 minutes; in about 94 per cent of the grains and 99 per cent of the total starch in 15 minutes; and in 100 per cent of the grains and total starch in 30 minutes. (Chart D 354.)

The hilum becomes distinct, attended by the formation of a bubble in more grains than in either parent. In this characteristic the hybrid more closely resembles *L. maculatum*. The lamellæ, as in both parents, are not visible. Gelatinization begins at the distal margin and progresses as in *L. maculatum*, except that the proximal end is gelatinized immediately in fewer grains than in *L. maculatum*, and the portion just distal to the hilum, which is the last part of the grain to be gelatinized, is split into two parts in some grains, as in some grains of *L. martagon*. The gelatinized grains are as much swollen, have as thin capsules, and are as much distorted as in *L. maculatum*. In this reaction *L. dalhansoni* shows qualitatively a closer relationship to *L. maculatum* than to *L. martagon*.

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 57 per cent of the entire number of grains and 90 per cent of the total starch in 3 minutes; in about 81 per cent of the grains and 95 per cent of the total starch in 5 minutes; and in about 98 per cent of the grains and in more than 99 per cent of the total starch in 15 minutes. (Chart D 355.)

The hilum becomes distinct unattended by the formation of a bubble in any of the grains, in this respect more nearly resembling *L. martagon*. The lamellæ are as distinct as in both parents. Gelatinization begins at the hilum and progresses according to the method described under *L. martagon*, except a few grains in which the process is the same as in *L. maculatum*.

In this reaction *L. dalhansoni* shows qualitatively a somewhat closer relationship to *L. martagon* than to *L. maculatum*.

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 65 per cent of the entire number of grains and 95 per cent of the total starch in 5 minutes, and in about 93 per cent of the grains and in more than 99 per cent of the total starch in 15 minutes. (Chart D 356.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in more than 99 per cent of the grains and total starch in 15 seconds, and in 100 per cent of the grains and total starch in 30 seconds.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 96 per cent of the entire number of grains and 98 per cent of the total starch in 30 seconds, and in 100 per cent of the grains and total starch in 45 seconds.

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in more than 99 per cent of the grains and total starch in 15 seconds. These very rare ungelatinized grains may resist the reaction for 5 minutes or longer.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in more than 99 per cent of the entire number of grains and total starch in 10 seconds. The very rare grains are quite resistant.

The hilum becomes distinct in all the grains, unaccompanied by the formation of a bubble in any of the grains as in *L. martagon*. The lamellæ are as distinct as in *L. martagon*. Gelatinization begins at the hilum and progresses as in *L. martagon*, except that somewhat more distinct and more extensive fissuring is noted in that portion of the grain included between 2 fissures proceeding from the hilum than in a similar portion of the grains of *L. martagon*. This shows that some influence is due to the other parent, *L. maculatum*. The gelatinized grains are as much swollen, have as thin capsules, and are as much distorted as in *L. martagon*. In this reaction *L. dalhansoni* shows qualitatively a closer relationship to *L. martagon* than to *L. maculatum*.

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 88 per cent of the entire number of grains and 95 per cent of the total starch in 30 seconds; in more than 99 per cent of the grains and total starch in 45 seconds; and in 100 per cent of the grains and total starch in 1 minute.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 86 per cent of the entire number of grains and 96 per cent of the total starch in 15 seconds; in about 97 per cent of the grains and 99 per cent of the total starch in 30 seconds; and in more than 99 per cent of the grains and total starch in 1 minute. Very rare grains resist gelatinization for 5 minutes or longer.

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in more than 99 per cent of the grains and total starch in 10 seconds. Very rare grains are quite resistant.

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 91 per cent of the entire number of grains and 97 per cent of the total starch in 15 seconds, and in more than 99 per cent of the grains and total starch in 25 seconds.

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 90 per cent of the entire number of grains and 98 per cent of

the total starch in 15 seconds; in about 96 per cent of the grains and 99 per cent of the total starch in 30 seconds; and in more than 99 per cent of the grains and total starch in 45 seconds. Rare resistant grains are generally gelatinized in 2 minutes.

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 69 per cent of the entire number of grains and 82 per cent of the total starch in 3 minutes; in about 96 per cent of the grains and 99 per cent of the total starch in 5 minutes; and in more than 99 per cent of the grains and total starch in 10 minutes. (Chart D 358.)

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 44 per cent of the entire number of grains and 84 per cent of the total starch in 1 minute; in about 85 per cent of the grains and 98 per cent of the total starch in 3 minutes; and in about 99 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes.

The reaction with *uranium nitrate* begins immediately. Complete gelatinization occurs in about 60 per cent of the entire number of grains and 72 per cent of the total starch in 1 minute; in about 92 per cent of the grains and 98 per cent of the total starch in 3 minutes; and in about 95 per cent of the grains and 99 per cent of the total starch in 5 minutes.

The reaction with *strontium nitrate* begins in 15 seconds. Complete gelatinization occurs in about 71 per cent of the entire number of grains and 78 per cent of the total starch in 1 minute, and in more than 99 per cent of the grains and total starch in 3 minutes.

The reaction with *cobalt nitrate* begins immediately. Complete gelatinization occurs in about 47 per cent of the entire number of grains and 58 per cent of the total starch in 1 minute; in about 75 per cent of the grains and 95 per cent of the total starch in 3 minutes; and in about 92 per cent of the grains and 98 per cent of the total starch in 5 minutes. (Chart D 359.)

The hilum becomes distinct in all the grains, attended by the formation of a bubble in a moderate number, as in *L. martagon*. The lamellæ also are as distinct as in that starch. Gelatinization begins at the hilum and proceeds as in *L. martagon*, except that the marginal band formed at the proximal end and sides nearby usually does not show any lamellar markings as in *L. maculatum*. The gelatinized grains are as much swollen, have somewhat thinner capsules than in *L. martagon* but not so thin as in *L. maculatum*, and are usually as much distorted at the distal end as in *L. martagon*. In this reaction *L. dalhansoni* shows qualitatively a somewhat closer relationship to *L. martagon* than to *L. maculatum*.

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 81 per cent of the entire number of grains and 94 per cent of the total starch in 1 minute, and in more than 99 per cent of the grains and total starch in 3 minutes.

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 52 per cent of the entire number of grains and 78 per cent of the total starch in 1 minute, and in about 96 per cent of the grains and in more than 99 per cent of the total starch in 3 minutes.

The hilum becomes distinct in all the grains, attended by the formation of a bubble in a moderate minority as in *L. maculatum*. The lamellæ are as distinct as in *L. martagon*. Gelatinization begins at the hilum and progresses as in *L. martagon*, except that the fissuring is not so distinct and the granular residue not so refractive as in that starch. In these two respects the hybrid more nearly resembles *L. maculatum*. The gelatinized grains are as much swollen, have as thick capsules, and are as much distorted as in *L. martagon*. In this reaction *L. dalhansoni* shows qualitatively a somewhat closer relationship to *L. martagon* than to *L. maculatum*.

The reaction with *barium chloride* begins immediately. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 16 per cent of the total starch in 1 minute; in about 66 per cent of the grains and 89 per cent of the total starch in 3 minutes; in about 86 per cent of the grains and 97 per cent of the total starch in 5 minutes; and in about 98 per cent of the grains and in more than 99 per cent of the total starch in 15 minutes. (Chart D 360.)

The reaction with *mercuric chloride* begins immediately. Complete gelatinization occurs in about 56 per cent of the entire number of grains and 84 per cent of the total starch in 30 seconds; in about 75 per cent of the grains and 95 per cent of the total starch in 1 minute; and in more than 99 per cent of the grains and total starch in 3 minutes.

27. Starches of Lilium tenuifolium, L. martagon album, and L. golden gleam.

Starch of *L. martagon album* (pollen parent) is described on pages 598 to 601.

Lilium tenuifolium (Seed Parent).

(Plate 16, fig. 94; Charts D 361 to D 366.)

Histologic Properties.

The grains are usually simple in *form* and isolated, but there are a very few compound grains and occasional aggregates. The compound grains belong to one type: 2 very small grains, each consisting of a hilum and 1 or 2 lamellæ, become adherent and surrounded by 20 to 30 common secondary lamellæ, and attached to the proximal end of a long grain. The aggregates are in the forms of doublets or triplets pyramidally arranged. The grains are usually somewhat irregular and the irregularities are due to the following causes: (1) Small elevations and depressions of the surface, more frequently at the distal end, but sometimes of the whole surface; (2) a shifting of the longitudinal axis, with a consequent curvature in the middle or at the distal end of the grain; (3) a large, rounded or pointed protuberance from the proximal end or from the sides; (4) a greater development of one part of the distal end than of the rest. The conspicuous forms are elongated and pure ovoid, broad and narrow pyriform, and elliptical with flattened distal end, or with both ends rounded. The additional forms are clam-shell-shaped, nearly round, irregularly quadrilateral with rounded angles, club-shaped, and triangular with rounded angles. The broader forms are somewhat flattened, and when viewed on edge are elongated ovoid in shape.

The *hilum* when not fissured or occupied by a cavity is a distinct, round, or lenticular-shaped spot. It is usually occupied by a cavity from which 2 delicate fissures or furrows extend toward the distal end, and is occasion-

ally marked by a small, straight, transverse or oblique fissure. The hilum is eccentric from 0.33 to 0.12, usually 0.2, of the longitudinal axis.

The *lamellæ* are usually fine and not very distinct. Those directly around the hilum are continuous and have a round or oval form. The rest have the form of the outline of the grain, and when near the distal end are less fine, more distinct, and appear to be discontinuous. There is often one broad, refractive, and very distinct lamella situated about two-thirds to three-fourths of the distance from the hilum to the distal margin which separates the fine proximal lamellæ from those not so fine and more distinct at the distal end. Sometimes there are 3 or 5 such broad refractive lamellæ which divide the fine lamellæ into bands of varying breadth. The number counted on the larger grains varies from 30 to 52, usually 36.

The *size* of the grains varies from the smaller which are 5 by 5μ, to the larger which are 50 by 36μ and 50 by 48μ, in length and breadth. The common size is 28 by 21μ.

Comparison of the *histologic properties* between *L. martagon album* and *L. tenuifolium* shows:

Form: A very few compound grains and aggregates of the same types as in *L. tenuifolium* are seen. The grains are more regular in form, but any irregularities are due to the same causes as in *L. tenuifolium.* Protuberances from the sides or ends of the grain are much swollen and more rounded than in *L. tenuifolium.* The grains are less varied in form, and dome-shaped and lenticular forms occur which are not seen in *L. tenuifolium.* Fewer of the grains are flattened, but when such grains are viewed on edge their form is the same as in *L. tenuifolium.*

The *hilum* is not so distinct as in *L. tenuifolium.* It is less often occupied by a cavity, but somewhat more often fissured than in *L. tenuifolium,* and the fissures have the forms of: (1) A small, straight, transverse line; (2) a flying-bird. In a few grains two fissures, apparently on opposite sides of the grain, are observed. The hilum is somewhat less eccentric, being commonly centric, usually 0.22 of the longitudinal axis.

The *lamellæ* have the same characteristics and arrangement as in *L. tenuifolium,* but they are more numerous.

In *size* the grains are somewhat larger than those of *L. tenuifolium,* the common size being 30 by 19μ in length and breadth.

Polariscopic Properties.

The *figure* is distinct and usually well defined. The lines cross at a very acute angle which does not vary greatly in size in the different grains, and they are often very much bent, but rarely bisected.

The *degree of polarization* varies from low to high (value 50); in most of the grains it is moderate, and in a few it is low, and in a few others it is high. There is occasionally some variation in a given aspect of an individual grain.

With *selenite* the quadrants are usually clear-cut. They are very unequal in size and often irregular in shape. The colors are usually not pure, the yellow being less pure than the blue.

Comparison of the *polariscopic properties* between *L. martagon album* and *L. tenuifolium* shows:

The *figure* is as distinct and is always well defined, the lines do not cross at such an acute angle, and are not so often bent as in *L. tenuifolium.*

The *degree of polarization* varies from low to high (value 65) and there are more grains in which it is high and fewer in which it is moderate than in *L. tenuifolium.* It is much higher than in *L. tenuifolium.*

With *selenite* the quadrants are more often clear-cut, and not so unequal in size nor so often irregular in shape as in *L. tenuifolium.* The colors are usually pure instead of the reverse as in *L. tenuifolium.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate violet tinged with blue (value 55), and the color deepens rapidly until it is very deep and much more bluish. With 0.125 per cent Lugol's solution the grains all color a light violet tinged with blue, and the color deepens very rapidly until it is very deep and much more bluish. After heating in water until the grains are all gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* all color a light indigo, and the *solution* a very deep indigo. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, some of the *grain-residues* color a very light indigo, but most of them are not colored, excepting the capsules; the *capsules* all color a red or a reddish violet, and the *solution* a very deep indigo.

Comparison of the *iodine reactions* between *L. martagon album* and *L. tenuifolium* shows:

With a 0.25 per cent Lugol's solution the grains color much more (value 65), and with more of a bluish tint; so also with a 0.125 per cent Lugol's solution. After heating in water until the grains are all gelatinized, most of the gelatinized grains color a light and some a moderate indigo-blue, more than in *L. tenuifolium,* and the solution a deep indigo, somewhat less than in *L. tenuifolium.* If the preparation is treated with an excess of a 2 per cent Lugol's solution, more of the grain-residues color light indigo than in *L. tenuifolium;* the capsules and the solution color the same as in *L. tenuifolium.*

Aniline Reactions.

With *gentian violet* the grains all color very lightly in 1 minute, and in 30 minutes the majority are moderately and a few deeply colored (value 60). The grains are usually colored more at the distal than at the proximal end.

With *safranin* the grains all color very lightly in 1 minute, and in 30 minutes the majority are moderately and a very few deeply colored (value 55), less than with gentian violet. The grains are usually colored more at the distal than at the proximal end.

Comparison of the *aniline reactions* between *L. martagon* and *L. tenuifolium* shows:

With *gentian violet* the grains all color moderate to deeply (value 55), less than in *L. tenuifolium.*

With *safranin* most of the grains color moderately and a few deeply (value 50), somewhat less than in *L. tenuifolium.*

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 52° to 53° C., and of all is 55.6° to 56° C., mean 55.8° C.

Comparison of the *temperature reactions* between *L. martagon album* and *L. tenuifolium* shows:

The temperature of gelatinization is higher than that of *L. tenuifolium*, 62° to 64° C., mean 63° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 30 seconds. Complete gelatinization occurs in about 23 per cent of the entire number of grains and 68 per cent of the total starch in 5 minutes; in about 80 per cent of the grains and 97 per cent of the total starch in 15 minutes; and in about 98 per cent of the grains and in more than 99 per cent of the total starch in 30 minutes. (Chart D 361.)

The hilum becomes distinct, attended by the formation of a bubble in a majority of the grains. The lamellæ are usually not visible, but in some of the grains they are moderately distinct. The grains become more refractive after the addition of the reagent, and the first part of the grain to show this increased refractivity is a narrow strip at the margin. Gelatinization begins at one or two isolated points on the distal margin, and from these points it extends around the margin, only the extreme marginal material being affected. Gelatinization is attended by much swelling and distortion of the capsule. One or two groups of lamellæ at the distal end are separated from the rest and gelatinized. After this, gelatinization progresses smoothly inward from all sides. The last part of the grain to be gelatinized is that just distal to the hilum. This is invaded by irregular fissures and appears to be eroded at several points and is finally completely gelatinized. The gelatinized grains are much swollen, have rather thick capsules, and are very much distorted. They bear no resemblance to the form of the untreated grain.

Comparison of the *chloral-hydrate* reactions between *L. martagon album* and *L. tenuifolium* shows:

A bubble is formed at the hilum in a small minority of the grains instead of in a majority as in *L. tenuifolium*, and the lamellæ are never visible. The grain does not become so refractive after the addition of the reagent, and the strip of starch at the margin which first shows this change is broader than a similar strip in *L. tenuifolium*. Gelatinization begins at the distal end and progresses around the margin more rapidly than in the interior of the grain, but a wider layer of the marginal material is gelatinized than in *L. tenuifolium*. Gelatinization is preceded by the formation of shallow depressions in the margin and by a pitted appearance of the surface of the ungelatinized starch. The last part of the grain to be gelatinized is, as in *L. tenuifolium*, the portion just distal to the hilum, and this is often split into two pieces which are gelatinized independently of one another. This is never seen in *L. tenuifolium*. The gelatinized grains are as much swollen and have as thick capsules as in *L. tenuifolium*. They are even more distorted than in that starch and bear no resemblance to the form of the untreated grain.

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 77 per cent of the entire number of grains and 95 per cent of the total starch in 3 minutes; in about 81 per cent of the grains and 98 per cent of the total starch in 5 minutes; and in about 98 per cent of the grains and in more than 99 per cent of the total starch in 15 minutes. (Chart D 362.)

The hilum becomes distinct in all the grains, attended by the formation of a bubble in very few. The lamellæ are moderately distinct. The hilum begins to swell much more rapidly toward the proximal than the distal end of the grain. Two fissures extend from either side of the hilum nearly to the distal margin. The starch included between them is extensively fissured by a number of fine branching fissures and is then rapidly gelatinized. As the grain swells the residue of this starch forms a refractive granular mass at the distal end which is often gelatinized before dissolution of the grain. The portion at the proximal end and sides forms a refractive homogeneous-looking band at the margin which is thinner at the proximal end. It is finally dissolved at this point, and solution proceeds toward the distal end; the last part to be dissolved being the thin capsule at the distal end.

Comparison of the *chromic-acid* reactions between *L. martagon album* and *L. tenuifolium* shows:

There are as few grains in which a bubble is formed at the hilum as in *L. tenuifolium*, and the lamellæ are more distinct than in that starch. Gelatinization proceeds in an essentially similar fashion. The differences noted are that the fissures extending from the hilum on either side toward the distal end are much shorter and the material comprehended between them is more distinctly and somewhat more irregularly fissured, and the granular residue at the distal end is much less distinctly granular and is also more resistant, often being nearly the last part of the grain to be dissolved.

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 93 per cent of the entire number of grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 365.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 98 per cent of the entire number of grains and 99 per cent of the total starch in 15 seconds, and in 100 per cent of the grains and total starch in 30 seconds.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 88 per cent of the entire number of grains and 96 per cent of the total starch in 30 seconds, and in more than 99 per cent of the grains and total starch in 45 seconds.

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 95 per cent of the entire number of grains and 98 per cent of the total starch in 15 seconds, and in 100 per cent of the grains and total starch in 30 seconds.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in more than 99 per cent of the entire number of grains and total starch in 10 seconds, and in 100 per cent of the grains and total starch in 15 seconds.

The hilum becomes distinct in all the grains, unattended by the formation of a bubble in any. The lamellæ are distinct. Gelatinization begins at the hilum which swells more rapidly toward the proximal than toward the distal end. Two fissures extend from either side of

the hilum one-half to three-fourths of the distance from the hilum to the distal margin, and the starch comprehended between them is divided by fine, branching fissures. It then gelatinizes very rapidly, accompanied by great swelling of the grains. A residue consisting of many refractive granules is left at the distal margin of the grains, and this is gelatinized less rapidly, with considerable infolding and distortion of that part of the grain. The material at the proximal margin and sides forms a faintly lamellated, refractive band which gradually becomes thinner and more nearly transparent until it is gelatinized. The gelatinized grains are much swollen, have rather thin capsules, and are very much distorted, particularly at the distal end.

Comparison of the *potassium-hydroxide* reactions between *L. martagon album* and *L. tenuifolium* shows:

No bubble is formed at the hilum as in *L. tenuifolium*. The lamellæ are less distinct than in those grains. The method of gelatinization is very much the same as in *L. tenuifolium*. The differences noted are that the starch included between the 2 fissures which proceed from the hilum is not so distinctly fissured and does not gelatinize so rapidly. The residue remaining after gelatinization is not definitely granular, but is merely an irregular, refractive mass, which is often the last part of the grain to be gelatinized. The gelatinized grains are as much swollen, have as thin capsules, and are somewhat less distorted than in *L. tenuifolium*.

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 94 per cent of the entire number of grains and 98 per cent of the total starch in 30 seconds, and in 100 per cent of the grains and total starch in 1 minute.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 71 per cent of the entire number of grains and 85 per cent of the total starch in 15 seconds; in about 94 per cent of the grains and 99 per cent of the total starch in 30 seconds; and in 100 per cent of the grains and total starch in 1 minute.

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 54 per cent of the entire number of grains and 92 per cent of the total starch in 15 seconds; in about 65 per cent of the entire number of grains and 96 per cent of the total starch in 30 seconds; in about 69 per cent of the grains and 97 per cent of the total starch in 1 minute; and in about 79 per cent of the grains and 99 per cent of the total starch in 3 minutes; little further change for 5 minutes. The outermost layer of the grains in this starch becomes very refractive and is very resistant, and the wall remains heavier and is less distorted than in the starches of the other species.

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 86 per cent of the entire number of grains and 96 per cent of the total starch in 15 seconds, and in 100 per cent of the grains and total starch in 30 seconds.

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 84 per cent of the entire number of grains and 96 per cent of the total starch in 15 seconds; in about 94 per cent of the grains and 98 per cent of the total starch in 30 seconds; and in more than 99 per cent of the grains and total starch in 45 seconds. Rare resistant grains become completely gelatinized in 1 minute and 15 seconds.

The reaction with *sodium salicylate* begins in 30 seconds. Complete gelatinization occurs in about 43 per cent of the entire number of grains and 53 per cent of the total starch in 3 minutes; in about 72 per cent of the grains and 83 per cent of the total starch in 5 minutes; and in about 99 per cent of the grains and in more than 99 per cent of the total starch in 10 minutes. (Chart D 363.)

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 50 per cent of the entire number of grains and 71 per cent of the total starch in 1 minute; in about 79 per cent of the grains and 98 per cent of the total starch in 3 minutes; and in about 98 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes.

The reaction with *uranium nitrate* begins in 15 seconds. Complete gelatinization occurs in about 73 per cent of the entire number of grains and 83 per cent of the total starch in 1 minute, and in about 98 per cent of the grains and in more than 99 per cent of the total starch in 3 minutes.

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 88 per cent of the entire number of grains and 96 per cent of the total starch in 1 minute, and in 100 per cent of the grains and total starch in 3 minutes.

The reaction with *cobalt nitrate* begins immediately. Complete gelatinization occurs in about 64 per cent of the entire number of grains and 71 per cent of the total starch in 1 minute; in about 70 per cent of the grains and 95 per cent of the total starch in 3 minutes; and in about 95 per cent of the grains and 98 per cent of the total starch in 5 minutes.

The hilum becomes distinct in all, attended by the formation of a bubble in a majority of the grains. The lamellæ are distinct. Gelatinization begins at the hilum, which swells toward the proximal end and 2 short fissures proceed obliquely from either side of the hilum in the direction of the distal margin. The starch between these 2 fissures is divided by very distinct, rather irregular longitudinal and oblique fissures which divide it into granules. It is then quickly gelatinized, leaving a small granular residue at the distal end. The starch at the proximal end and sides, meanwhile, is pushed to the margin, where it forms a refractive, indistinctly lamellated band which soon loses its lamellated appearance and rapidly grows thinner and more nearly transparent until it is gelatinized. The small granular mass at the distal end is later gelatinized with some infolding and distortion of the capsule at this point. The gelatinized grains are much swollen, have moderately thin capsules, and are usually not greatly distorted, but sometimes are considerably distorted at the distal end.

Comparison of the *cobalt-nitrate* reactions between *L. martagon album* and *L. tenuifolium* shows:

A bubble is not so often formed at the hilum, but the lamellæ are as distinct as in *L. tenuifolium*. Gelatinization begins at the hilum, which swells especially toward the proximal end, and unlike in *L. tenuifolium* becomes invaginated at first and later is pushed out. Two fissures extend obliquely from either side of the

hilum toward the distal margin, the material between them is less rapidly gelatinized and less distinctly fissured than in *L. tenuifolium,* and forms a larger granular mass at the distal end of the grains, than in that starch. This mass as the grain swells is divided by wedge-shaped fissures into a serrated inner border to the marginal band of material at the distal end, and this is not seen in any of the grains of *L. tenuifolium.* Otherwise the process of gelatinization is the same in the two starches. The gelatinized grains are as much swollen, do not have such thin capsules, and are much more distorted at the distal end than in that starch.

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 67 per cent of the entire number of grains and 90 per cent of the total starch in 1 minute, and in 99 per cent of the grains and more than 99 per cent of the total starch in 3 minutes.

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 57 per cent of the entire number of grains and 70 per cent of the total starch in 1 minute; in about 80 per cent of the grains and 95 per cent of the total starch in 3 minutes; and in about 98 per cent of the grains and 99 per cent of the total starch in 5 minutes.

The hilum becomes distinct, attended by the formation of a bubble in the majority of the grains. The lamellæ are very distinct. Gelatinization begins at the hilum, which swells more rapidly in the direction of the proximal than the distal end. As it swells an invagination pushes in from either side, but is later pushed out again. Two fissures extend obliquely from either side of the hilum about three-fourths of the distance from the hilum to the margin. The starch included between them becomes a mass of irregular granules into which 3 or 4 rather indistinct fissures extend. This gelatinizes comparatively slowly and leaves rather a large residue of refractive indistinctly granular material at the distal end of the grain. The starch at the proximal and distal margins and sides forms a rather thick, homogeneous-looking, refractive band which gradually grows thinner and more nearly transparent until it is gelatinized, leaving only the capsule. The refractive granular mass at the distal margin is the last to be gelatinized. The gelatinized grains are much swollen, have rather thick capsules, and are greatly distorted especially at the distal end.

Comparison of the *cupric-chloride* reactions between *L. martagon album* and *L. tenuifolium* shows:

A bubble is less often formed at the hilum, and the lamellæ are less distinct, than in *L. tenuifolium.* Gelatinization is not very different from the process noted in *L. tenuifolium.* The differences are that the starch included between the 2 original fissures which extend from the hilum is more distinctly fissured, is gelatinized more easily, and leaves a smaller granular refractive residue at the distal end which is usually gelatinized before instead of after the marginal material. The starch at the margin forms a thicker and less refractive band than in *L. tenuifolium.* The gelatinized grains are as much swollen, have as thick capsules, and are somewhat more distorted than in *L. martagon album.*

The reaction with *barium chloride* begins immediately. Complete gelatinization occurs in about 61 per cent of the entire number of grains and 66 per cent of the total starch in 1 minute; in about 72 per cent of the grains and 88 per cent of the total starch in 3 minutes; in about 88 per cent of the grains and 96 per cent of the total starch in 5 minutes; and in about 99 per cent of the grains and in more than 99 per cent of the total starch in 15 minutes. (Chart D 364.)

The reaction with *mercuric chloride* begins immediately. Complete gelatinization occurs in about 66 per cent of the entire number of grains and 90 per cent of the total starch in 30 seconds; in about 85 per cent of the grains and 97 per cent of the total starch in 1 minute; and in 100 per cent of the grains and total starch in 3 minutes.

Lilium golden gleam (Hybrid).

(Plate 16, fig. 96; Charts D 361 to D 366.)

Histologic Properties.

In *form* the grains are usually simple and isolated. A very few compound grains of the type described under both parents occur, but no aggregates are seen. The grains are more irregular in form than in either parent, and in this characteristic show a closer resemblance to *L. tenuifolium* than to *L. martagon album.* The irregularities are due to the following causes: (1) Small depressions and elevations in the surface, usually more numerous at the distal end; (2) a rounded or pointed protuberance from either side or from proximal end; (3) the greater development of one part of the distal end than of the rest, all of which causes with the addition of one or two others are evident in both parents. The conspicuous forms are pure and elongated ovoid, ellipsoidal with flattened or rounded distal end, and both broad and narrow pyriform. The additional forms are clam-shell-shaped, club-shaped, nearly round, oyster-shell-shaped, and finger-shaped grains. The broad, flattened forms are not quite so numerous as in *L. tenuifolium,* but more numerous than in *L. martagon album.* In form *L. golden gleam* shows a closer relationship to *L. tenuifolium* than to *L. martagon album.*

The *hilum* when not fissured is as distinct as in *L. tenuifolium* and is more often and more extensively fissured than in either parent, and in this respect is somewhat closer to *L. martagon album* than to *L. tenuifolium.* The fissures have the following forms: (1) A single, straight, transverse or oblique line; (2) cruciate, **Y**-, or **T**-shaped; (3) a flying-bird figure. The hilum is eccentric from 0.4 to 0.18, usually 0.27, of the longitudinal axis.

In the character of the hilum when not fissured and in eccentricity *L. golden gleam* shows a closer relationship to *L. tenuifolium* than to *L. martagon album.* The hilum in the hybrid is much more fissured than in either parent. Those of the latter resemble one another more closely than the hila of the hybrid resemble those of either parent. Eccentricity is less than in either parent.

The *lamellæ* are not distinct and not so fine as in either parent. In arrangement they are the same as in both parents. The number counted on the larger grains varies from 20 to 30, usually 25, which is distinctly less than in either parent.

The lamellæ do not resemble those of either parent so closely as the parents resemble one another, but, on the whole, are more closely related to *L. tenuifolium.*

In *size* the grains vary from the smaller which are 6 by 6μ, to the larger which are 40 by 30μ and 44 by 40μ, in length and breadth. The common size is 28 by 19μ.

In size *L. golden gleam* shows a closer relationship to *L. tenuifolium* than to *L. martagon album.*

Polariscopic Properties.

The *figure* is as distinct and more often well defined than in *L. tenuifolium,* but not so often as in *L. martagon album.* The lines cross at a very acute angle, as in *L. tenuifolium,* which does not vary greatly in size in the different grains. They are somewhat more often bent than in *L. tenuifolium* and much more than in *L. martagon album,* but are not often bisected.

The *degree of polarization* varies from low to high (value 45), somewhat less than in *L. tenuifolium* and much less than in *L. martagon album,* as there are fewer grains in which it is high than in either parent. There is as in *L. tenuifolium* some variation in a given aspect of an individual grain.

With *selenite* the quadrants are more often clear-cut and somewhat more irregular in shape than in that starch. The colors are not so often pure as in *L. tenuifolium.*

In the character of the figure, the degree of polarization, and the appearances with selenite *L. golden gleam* shows qualitatively a closer relationship to *L. tenuifolium* than to *L. martagon album.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate blue-violet (value 50), somewhat less than in *L. tenuifolium* and much less than in *L. martagon album.* With 0.125 per cent Lugol's solution the grains all color a light blue-violet, less than in either parent. After heating in water until the grains are all gelatinized, most of the gelatinized *grains* color a light indigo-blue, and the *solution* a very deep indigo-blue, as in *L. tenuifolium.* If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, some of the *grain-residues* color a very light indigo, but most of them are not colored except in the capsules; the *capsules* color a red or reddish violet, and the *solution* a very deep indigo-blue, as in *L. tenuifolium.* Qualitatively and quantitatively the reactions with iodine show a closer relationship to *L. tenuifolium* than to *L. martagon album.*

Aniline Reactions.

With *gentian violet* the grains all color very lightly in 1 minute, and in 30 minutes the majority are light to moderately and a few deeply colored (value 45), less than in either parent but closer to *L. martagon album.* The grains are usually colored more at the distal than at the proximal end as in both parents.

With *safranin* the grains all color very lightly in 1 minute, and in 30 minutes the majority are light to moderately colored and a few deeply colored (value 48), less than in either parent but nearer to *L. martagon album.* The grains are usually colored more at the distal than at the proximal end.

In the reactions with aniline stains *L. golden gleam* shows a closer relationship to *L. martagon album* than to *L. tenuifolium.*

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 53° to 54.4° C., and of all 57° to 58.7° C.; the mean is 57.8° C. The temperature of gelatinization of *L. golden gleam* is intermediate between that of *L. tenuifolium* and *L. martagon album,* but is closer to *L. tenuifolium* than to *L. martagon album.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 30 seconds. Complete gelatinization occurs in about 29 per cent of the entire number of grains and 52 per cent of the total starch in 5 minutes; in about 65 per cent of the grains and 83 per cent of the total starch in 15 minutes; and in about 91 per cent of the grains and 97 per cent of the total starch in 30 minutes. (Chart D 361.)

The hilum becomes distinct, attended by the formation of a bubble in more grains than in either parent, in which characteristic the hybrid shows a closer relationship to *L. tenuifolium.* The lamellæ, as in *L. martagon album,* are never visible. The grain becomes more refractive, the first part to show this change, as in *L. martagon album,* is a rather broad strip at the margin. Gelatinization begins at the corners of the distal margin and progresses as in *L. martagon album,* except that the portion of the grain just distal to the hilum, which is the last to be gelatinized, is not so often split into two pieces before it is broken down. The gelatinized grains are as much swollen and have as thick capsules as in both parents and are as much distorted as in *L. martagon album,* but not so much as in *L. tenuifolium.* In this reaction *L. golden gleam* shows qualitatively a closer relationship to *L. martagon album* than to *L. tenuifolium.*

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 90 per cent of the entire number of grains and 98 per cent of the total starch in 3 minutes, and in about 97 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 362.)

The hilum, as in both parents, becomes distinct in all the grains, attended by the formation of a bubble in very rare grains. The lamellæ are as distinct as in *L. tenuifolium.* Gelatinization begins at the hilum and progresses as in *L. tenuifolium,* except that the material comprehended between the 2 fissures is less distinctly and even more irregularly fissured, and is even less resistant and more rapidly gelatinized, than the corresponding part of the grains of *L. tenuifolium.*

In this reaction *L. golden gleam* shows qualitatively a somewhat closer relationship to *L. tenuifolium* than to *L. martagon album.*

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 96 per cent of the entire number of grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 366.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in more than 99 per cent of the grains and total starch in 15 seconds, and in 100 per cent of the grains and total starch in 30 seconds.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 94 per cent of the entire number of grains and 98 per cent of the total

starch in 30 seconds, and in 100 per cent of the grains and total starch in 45 seconds.

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 99 per cent of the entire number of grains and in more than 99 per cent of the total starch in 15 seconds, and in 100 per cent of the grains and total starch in 30 seconds.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in 100 per cent of the grains and total starch in 10 seconds.

The hilum becomes more distinct in all the grains, unattended by the formation of a bubble, as in both parents. The lamellæ are distinct as in *L. tenuifolium.* Gelatinization begins at the hilum and progresses as in *L. tenuifolium,* except that the material comprehended between the 2 fissures which proceed from either side of the hilum is not so distinctly nor so irregularly fissured, and the granules composing the residue at the distal margin are not so refractive, showing the influence of *L. martagon album.* A few grains are gelatinized exactly as in *L. martagon album.* The gelatinized grains are not so much swollen as in either parent, have rather thick instead of fine capsules, and are not so much distorted as in *L. tenuifolium* but as much as in *L. martagon album.*

In this reaction *L. golden gleam* shows qualitatively a somewhat closer relationship to *L. tenuifolium* than to *L. martagon album.*

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 97 per cent of the entire number of grains and 99 per cent of the total starch in 30 seconds, and in all but very rare grains (more than 99 per cent) and total starch in 1 minute.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 96 per cent of the entire number of grains and 99 per cent of the total starch in 15 seconds, and in more than 100 per cent of the grains and total starch in 30 seconds.

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 92 per cent of the entire number of grains and 99 per cent of the total starch in 15 seconds, and in about 94 per cent of the grains and in more than 99 per cent of the total starch in 30 seconds; little further change is observed in 5 minutes and longer.

The reagent has the same effect on the outermost layers of the grain as is noted for a larger percentage of grains in *L. tenuifolium,* but is not observed in *L. martagon album.*

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in 100 per cent of the grains and total starch in 15 seconds.

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 90 per cent of the entire number of grains and 99 per cent of the total starch in 15 seconds; in about 99 per cent of the grains and in more than 99 per cent of the total starch in 30 seconds; and in 100 per cent of the grains and total starch in 60 seconds.

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 54 per cent of the entire number of grains and 63 per cent of the total starch in 3 minutes; in about 85 per cent of the grains and 93 per cent of the total starch in 5 minutes; and in about 99 per cent of the grains and in more than 99 per cent of the total starch in 10 minutes. (Chart D 363.)

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 82 per cent of the entire number of grains and 91 per cent of the total starch in 1 minute; in about 89 per cent of the grains and 98 per cent of the total starch in 3 minutes; and in more than 99 per cent of the grains and total starch in 5 minutes.

The reaction with *uranium nitrate* begins immediately. Complete gelatinization occurs in about 80 per cent of the entire number of grains and 88 per cent of the total starch in 1 minute, and in more than 99 per cent of the grains and total starch in 3 minutes.

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 84 per cent of the entire number of grains and 92 per cent of the total starch in 1 minute, and in more than 99 per cent of the grains and total starch in 3 minutes.

The reaction with *cobalt nitrate* begins immediately. Complete gelatinization occurs in about 66 per cent of the entire number of grains and 75 per cent of the total starch in 1 minute; in about 94 per cent of the grains and in more than 99 per cent of the total starch in 3 minutes; and in 100 per cent of the grains and total starch in 5 minutes.

The hilum becomes distinct in all the grains, attended by the formation of a bubble in as many grains as in *L. tenuifolium* and more than in *L. martagon album.* The lamellæ are distinct as in both parents. Gelatinization begins at the hilum and proceeds as in *L. tenuifolium,* except that in some grains the starch included between the 2 fissures which proceed from the hilum is less quickly gelatinized and more indistinctly and more irregularly fissured than in *L. tenuifolium,* but the same as in *L. martagon album.* The gelatinized grains are as much swollen, have as thin capsules, and are as little distorted as in *L. tenuifolium.*

In this reaction *L. golden gleam* shows qualitatively a closer relationship to *L. tenuifolium* than to *L. martagon album.*

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 92 per cent of the entire number of grains and 99 per cent of the total starch in 1 minute, and in 100 per cent of the grains and total starch in 3 minutes.

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 65 per cent of the entire number of grains and 82 per cent of the total starch in 1 minute; in about 97 per cent of the grains and in more than 99 per cent of the total starch in 3 minutes; and in more than 99 per cent of the grains and total starch in 5 minutes.

The hilum becomes distinct, attended by the formation of a bubble in the great majority of the grains, as in *L. tenuifolium.* The lamellæ are usually not so distinct as in either parent, in this respect more nearly resembling *L. martagon album.* Gelatinization begins at the hilum and progresses as in *L. tenuifolium.* The gelatinized grains are as much swollen, have as thick capsules, and are as much distorted as in *L. tenuifolium.* In this

reaction *L. golden gleam* shows qualitatively a closer relationship to *L. tenuifolium* than to *L. martagon album*.

The reaction with *barium chloride* begins immediately. Complete gelatinization occurs in about 60 per cent of the entire number of grains and 82 per cent of the total starch in 1 minute; in about 97 per cent of the grains and 99 per cent of the total starch in 3 minutes; and in about 98 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 349.)

The reaction with *mercuric chloride* begins immediately. Complete gelatinization occurs in about 71 per cent of the entire number of grains and 84 per cent of the total starch in 30 seconds; in about 91 per cent of the grains and 98 per cent of the total starch in 1 minute; and in 100 per cent of the grains and total starch in 3 minutes.

28. Starches of Lilium chalcedonicum, L. candidum, and L. testaceum.

Lilium chalcedonicum (Seed Parent).

(Plate 17, fig. 97; Charts D 367 to D 372.)

Histologic Properties.

In *form* the grains are simple and isolated, but neither compound grains nor aggregates is seen. They are usually regular in form, and any irregularities which occur are due to the following causes: (1) A greater development of one part of the distal end than the rest; (2) small, shallow depressions and elevations of the distal surface and margin; (3) a low rounded protuberance from one side. The conspicuous forms are narrow pointed ovoid, broad ovoid, and regular and irregular pyriform. There are also clam-shell-shaped, triangular, and quadrilateral forms with rounded angles, and nearly round. The grains are usually narrower and more pointed at the proximal end than at the distal end. Some of the broader forms are flattened, and when viewed on edge have an elongated elliptical or ovoid shape.

The *hilum* is a somewhat indistinct, small, round, or rarely, lenticular spot which is occasionally fissured. The fissure is always in the form of a short or long, straight, transverse line. The hilum is eccentric from 0.33 to 0.09, usually 0.13, of the longitudinal axis.

The *lamellæ* are rather fine, distinct rings, which near the hilum are round or oval in form. In other parts they have in general the form of the outline of the grain and appear to be discontinuous. They are often somewhat irregular, having a wavy or undulating character. There is usually one broad, refractive lamella, about one-half to two-thirds of the distance from the hilum to the distal margin, which divides the finer proximal lamellæ from those not so fine at the distal end. There are sometimes three or four such broad refractive lamellæ which divide the finer lamellæ into bands of varying breadth. The number of lamellæ counted on the larger grains varies from 33 to 53, usually 45.

In *size* the grains vary from the smaller which are 7 by 5μ, to the larger elongated forms which are 60 by 32μ, rarely 76 by 50μ, in length and breadth, and the larger broad forms which are 90 by 80μ, rarely, 69 by 61μ, in length and breadth. The common sizes are 44 by 26μ and 50 by 45μ.

Polariscopic Properties.

The *figure* is usually distinct, but is not very well defined. The lines are thick and cross rarely at right angles, and usually at acute angles of varying size. They are often bent and are sometimes bisected. The figure is sometimes in the form of a conjugate hyperbola, or of a long line bisected at both ends.

The *degree of polarization* varies from low to high (value 60). In most of the grains it is moderate or moderate to high. There is some variation in a given aspect of the individual grain.

With *selenite* the quadrants are not well defined, very unequal in size, and often irregular in shape. The colors are often pure; the yellow is less often pure than the blue.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate blue-violet (value 55). The color deepens rapidly until it is very deep and more bluish. With 0.125 per cent Lugol's solution the grains all color a light to moderate violet tinged with blue. The color deepens rapidly until it is deep and much more bluish. After heating in water until all the grains are completely gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* all color a moderate or a moderate to deep indigo, and the *solution* a moderate to deep indigo. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the *grain-residues* all color a very light or a light indigo; the *capsules* a red or a reddish violet; and the *solution* a very deep indigo.

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes the majority are moderately and a few deeply colored (value 60). In many grains the distal end is more deeply colored than the rest of the grain.

With *safranin* the grains all color very lightly at once, and in 30 minutes the majority are moderately and a few deeply colored (value 65), more than with gentian violet. In many grains the distal end is more deeply colored than the rest of the grain.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 59.2° to 61° C., and of all in 63° to 64° C., the mean is 63.5° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 1 minute. Complete gelatinization occurs in about 8 per cent of the entire number of grains and 54 per cent of the total starch in 5 minutes; in about 70 per cent of the grains and 90 per cent of the total starch in 15 minutes; and in about 94 per cent of the grains and 97 per cent of the total starch in 30 minutes. (Chart D 367.)

The hilum becomes distinct, attended by the formation of a small bubble in a moderate minority of the grains. The lamellæ are not visible in any of the grains. The grains become more refractive after the addition of the reagent and the first part of the grain to show this change is a broad strip of starch at the margin. Gelatinization begins at several points on the distal margin and then, quickly, at the proximal end. It pro-

gresses from these two points, preceded by small fissures which invade the ungelatinized starch and separate off small pieces which are then gelatinized. The last part of the grain to be gelatinized is that just distal to the hilum, and this is never split into two pieces, but is slowly gelatinized, as a whole, in the same manner as the rest of the grain. The gelatinized grains are much swollen, have rather thin capsules, and are greatly distorted; they do not bear any resemblance to the form of the untreated grain.

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 46 per cent of the entire number of grains and 85 per cent of the total starch in 3 minutes; in about 61 per cent of the grains and 89 per cent of the total starch in 5 minutes; and in about 94 per cent of the grains and 99 per cent of the total starch in 15 minutes. (Chart D 368.)

The hilum becomes distinct in all the grains, attended by the formation of a bubble in a few. The lamellæ are distinct. Gelatinization begins at the hilum, which swells more rapidly proximally than distally. Two fissures extend from either side of the hilum about three-fourths of the distance from the hilum to the distal margin, and the starch included between them is broken up into refractive irregular spicules by many distinct and irregularly branching fissures. The deposit at the proximal and distal margins and sides meanwhile forms a refractive, homogeneous-looking band, which is thinner at the proximal end than elsewhere. The inner spicular portion is now gelatinized, causing the grain to swell and leaving a residue of scattered refractive granules which are especially numerous at the distal end. The capsule and the marginal starch are dissolved at the distal end, and a broad band showing traces of a lamellar structure separates off from the inner granular part of the grain. This is dissolved and then the rest of the capsules, the inner granular part of the grain often being the last to dissolve.

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 11 per cent of the entire number of grains and 78 per cent of the total starch in 5 minutes: in about 67 per cent of the grains and 95 per cent of the total starch in 15 minutes; and in about 85 per cent of the grains and 98 per cent of the total starch in 30 minutes. (Chart D 369.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 94 per cent of the entire number of grains and 98 per cent of the total starch in 15 seconds, and in more than 99 per cent of the grains and total starch in 30 seconds. The rare scattered grains ungelatinized in 30 seconds may resist gelatinization for 5 minutes or longer.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 86 per cent of the entire number of grains and 95 per cent of the total starch in 30 seconds, and in more than 99 per cent of the grains and total starch in 1 minute.

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 91 per cent of the entire number of grains and 95 per cent of the total starch in 15 seconds, and in 100 per cent of the grains and total starch in 30 seconds.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in more than 99 per cent of the entire number of grains and total starch in 10 seconds, and in 100 per cent of the grains and total starch in 15 seconds.

The hilum becomes distinct in all the grains, unattended by the formation of a bubble in any. The lamellæ are distinct. The hilum is slightly distinct, and a fissure extends from either side one-half to three-fourths of the distance from the hilum to the distal margin. The portion included between these 2 fissures is streaked with very fine, branching fissures which are very numerous and become more and more distinct as the grain swells. In some grains the portion immediately distal to the hilum is divided into several divisions by a double row of fissures which slant proximally from the 2 original fissures extending from the hilum to the longitudinal axis of the grain. These divisions are quickly gelatinized and leave a residue of refractive granules. The rest of the fissured distal starch gelatinizes comparatively slowly, the fissures becoming more and more distinct. As the grain swells some of these fissures open out, dividing the starch into irregular pyramidal divisions and so forming a serrated inner border to the distal margin. The divisions are each fissured and may be divided into spicules. They remain for some little time and are finally gelatinized with much infolding and distortion of the capsule. The granules remaining from the gelatinization of the upper part of the starch distal to the hilum are also slowly gelatinized. The portion at the proximal margin and sides forms a rather thick, homogeneous-looking, refractive band which is slowly gelatinized. The gelatinized grains are greatly swollen, have thick capsules, and are very much distorted, particularly at the distal end, but sometimes in all parts of the capsule.

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 70 per cent of the entire number of grains and 85 per cent of the total starch in 30 seconds; in about 95 per cent of the grains and 99 per cent of the total starch in 1 minute; and in more than 99 per cent of the grains and total starch in 3 minutes. Rare resistant grains remain ungelatinized for 5 minutes or longer.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 53 per cent of the entire number of grains and 73 per cent of the total starch in 15 seconds; in about 75 per cent of the grains and 95 per cent of the total starch in 30 seconds; and in about 99 per cent of the grains and in more than 99 per cent of the total starch in 1 minute. Very rare grains remain ungelatinized for 2 minutes.

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 97 per cent of the entire number of grains and 99 per cent of the total starch in 15 seconds. Very rare grains may resist gelatinization for 5 minutes or longer.

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 79 per cent of the entire number of grains and 94 per cent of the total starch in 15 seconds, and in about 96 per cent of the grains and 99 per cent of the total starch in 30 seconds. Rare resistant grains may remain ungelatinized for 5 minutes or longer.

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 71 per

cent of the entire number of grains and 88 per cent of the total starch in 15 seconds; in about 86 per cent of the grains and 97 per cent of the total starch in 30 seconds; and in about 97 per cent of the grains and in more than 99 per cent of the total starch in 45 seconds. Rare resistant grains remain ungelatinized for 5 minutes or longer.

The reaction with *sodium salicylate* begins in 30 seconds. Complete gelatinization occurs in about 30 per cent of the entire number of grains and 40 per cent of the total starch in 3 minutes; in about 67 per cent of the grains and 90 per cent of the total starch in 5 minutes; and in about 99 per cent of the grains and in more than 99 per cent of the total starch in 10 minutes. (Chart D 370.)

The reaction with *calcium nitrate* begins in 30 seconds. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 24 per cent of the total starch in 1 minute; in about 76 per cent of the grains and 95 per cent of the total starch in 3 minutes; and in about 95 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes.

The reaction with *uranium nitrate* begins in 30 seconds. Complete gelatinization occurs in about 30 per cent of the entire number of grains and 45 per cent of the total starch in 1 minute, and in about 99 per cent of the grains and in more than 99 per cent of the total starch in 3 minutes.

The reaction with *strontium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 27 per cent of the entire number of grains and 54 per cent of the total starch in 1 minute, and in about 97 per cent of the grains and 98 per cent of the total starch in 3 minutes.

The reaction with *cobalt nitrate* begins in a few grains in 15 seconds. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 10 per cent of the total starch in 1 minute; in about 60 per cent of the grains and 90 per cent of the total starch in 3 minutes; in about 69 per cent of the grains and 95 per cent of the total starch in 5 minutes; and in about 95 per cent of the grains and 99 per cent of the total starch in 15 minutes. (Chart D 371.)

The hilum becomes distinct in all the grains, attended by the formation of a bubble in a great majority. The lamellæ are moderately distinct. Gelatinization begins at the hilum which swells more in the direction of the proximal end than toward the distal end. Two fissures extend obliquely from either side of the hilum about three-fourths of the distance from the hilum to the distal margin. The portion of the grain included between these two fissures is in turn traversed by many fine longitudinal and oblique fissures, which open out as the grain swells and so divide the portion that it forms a serrated border just above the distal marginal starch. The divisions of this border are in turn fissured and become granular, and as the grain continues to swell they all coalesce and form an irregular granular mass at the distal end of the swollen grain. The starch at the proximal and distal margins and sides forms a homogeneous-looking, refractive band which gradually grows smaller and more nearly transparent and is finally gelatinized. The granular mass at the distal end is often the last part of the grain to be completely gelatinized, a process which is accompanied by much infolding and distention of the capsule at this point. The gelatinized grains are very much swollen, have rather thick capsules, and are very much distorted at the distal end, but only slightly distorted at the proximal end.

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 70 per cent of the entire number of grains and 86 per cent of the total starch in 1 minute, and in about 98 per cent of the grains and 99 per cent of the total starch in 3 minutes.

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 20 per cent of the entire number of grains and 44 per cent of the total starch in 1 minute; in about 86 per cent of the grains and 98 per cent of the total starch in 3 minutes; and in more than 99 per cent of the grains and total starch in 5 minutes.

The hilum becomes distinct in all the grains, attended by the formation of a bubble in a large minority. The lamellæ are distinct. Gelatinization begins at the hilum which enlarges more rapidly toward the proximal than toward the distal end. The proximal end is after a time deeply invaginated and later pushed out again during the progress of gelatinization. Two fissures extend obliquely from either side of the hilum about three-fourths of the distance from the hilum to the distal margin and the portion included between them is divided by many irregular, branching fissures into a mass of granules which in part are gelatinized rapidly, leaving a residue of refractive granules at the distal end. These are gelatinized comparatively slowly, but usually before the marginal material. The marginal starch forms a thick, refractive, homogeneous-looking band, which slowly grows thinner and more nearly transparent until it is gelatinized. The gelatinized grains are much swollen, have thick capsules, and are greatly distorted, usually especially at the distal end, but sometimes in all parts of the grain.

The reaction with *barium chloride* begins in a few grains in 30 seconds. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 8 per cent of the total starch in 1 minute; in about 31 per cent of the grains and 71 per cent of the total starch in 3 minutes; in about 73 per cent of the grains and 89 per cent of the total starch in 5 minutes; and in about 90 per cent of the grains and 96 per cent of the total starch in 15 minutes. (Chart D 372.)

The reaction with *mercuric chloride* begins in 15 seconds. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 25 per cent of the total starch in 30 seconds; in about 72 per cent of the grains and 92 per cent of the total starch in 1 minute; and in about 99 per cent of the grains and in more than 99 per cent of the total starch in 3 minutes.

Lilium candidum (Pollen Parent).

(Plate 17, fig. 98; Charts D 367 to D 372.)

Histologic Properties.

In *form* the grains are always simple and isolated. There are no compound grains nor aggregates, but there are occasional simple grains which have one or two pressure facets on the distal end, so indicating the previous existence of aggregates. A larger majority of the grains are regular than in *L. chalcedonicum,* and any irregularities which may occur are due to the same causes as are

described for that starch. The conspicuous forms are broad and narrow ovoid, and ellipsoidal with flattened or rounded distal end. The additional forms are pyriform, clam-shell-shaped, triangular with rounded base, and nearly round. The tendency of the grain to be narower at the proximal than at the distal end which is so marked in *L. chalcedonicum* is present in this starch, but is not so marked. The broad forms are somewhat flattened as in *L. chalcedonicum* and when seen on edge have an elongated ovoid or ellipsoidal shape.

The *hilum* as in *L. chalcedonicum* is a small rather indistinct, round, or lenticular spot. It is more often fissured than in *L. chalcedonicum,* but the fissures have the same form, except that they may be curved instead of straight. The hilum is eccentric from 0.4 to 0.03, commonly 0.17, of the longitudinal axis. It is usually somewhat less eccentric than that of the grains of *L. chalcedonicum.*

The *lamellæ* are as fine but somewhat more distinct than those of *L. chalcedonicum.* The broad refractive lamellæ described under *L. chalcedonicum* are more numerous than in this starch, and there is often a band of 3 or 4 such lamellæ across the distal one-third of the grain. Otherwise they are the same as those of *L. chalcedonicum.* The number counted on the larger grains varies from 24 to 46, usually 42, somewhat less than in the other parent.

In *size* the grains vary from the smaller which are 6 by 6μ, to the larger broad forms which are 64 by 50μ, and the larger narrow forms which are 64 by 30μ, in length and breadth. The common size is 40 by 30μ. The sizes of the corresponding types are less than those of either parent.

Polariscopic Properties.

The *figure* is as distinct as in *L. chalcedonicum* and somewhat better defined. The lines more often cross at a right angle than in *L. chalcedonicum,* or at an acute angle whose size varies less in different grains than in that starch. They are less often bent or bisected than in *L. chalcedonicum.* The figure, also, is less often in the form of a conjugate hyperbole, or of a long line bisected at both ends than in that starch.

The *degree of polarization* varies from low to high (value 65), more than in *L. chalcedonicum,* as there are more grains in which it is high and fewer in which it is moderate than in that starch. There is the same amount of variation in a given aspect of an individual grain.

With *selenite* the quadrants are somewhat more clear-cut, and are less unequal in size and irregular in shape. The colors are more often pure than in *L. chalcedonicum.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains color a moderate to deep blue violet (value 65), more than in *L. chalcedonicum.* The color deepens very rapidly until it is very deep and more bluish. With 0.125 per cent Lugol's solution the grains all color a moderate violet tinged with blue, more than in *L. chalcedonicum.* The color deepens rapidly until it is very deep and more bluish. After heating in water until the grains are all completely gelatinized and treating with a 2 per cent Lugol's solution, the gelatinized *grains* all color a moderate indigo, less than in *L. chalcedonicum,* and the *solution* a deep indigo, more than in *L. chalcedonicum.* If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the majority of the *grain-residues* color a very light indigo, less than in *L. chalcedonicum,* and some do not color at all; the *capsules* a red or a reddish violet as in *L. chalcedonicum;* and the *solution* a very deep indigo as in *L. chalcedonicum.*

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes are moderately to very deeply colored (value 80), much more than in *L. chalcedonicum.* As in that starch they are often more deeply colored at the distal than at the proximal end.

With *safranin* the grains all color very lightly at once, and in 30 minutes they are moderately to very deeply colored (value 80), much more than in *L. chalcedonicum.* As in that starch, they are often more deeply colored at the distal than the proximal end.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 57° to 58.7° C., and of all is 60° to 62° C., the mean is 61° C. lower than those of the other parent.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 1 minute. Complete gelatinization occurs in about 14 per cent of the entire number of grains and 34 per cent of the total starch in 5 minutes; in about 34 per cent of the grains and 74 per cent of the total starch in 15 minutes; in about 66 per cent of the grains and 88 per cent of the total starch in 30 minutes; in about 77 per cent of the grains and 92 per cent of the total starch in 45 minutes; and in about 88 per cent of the grains and 95 per cent of the total starch in 60 minutes. (Chart D 367.)

The hilum becomes distinct, attended by the formation of a bubble in fewer grains than in *L. chalcedonicum.* The lamellæ are usually not visible as in *L. chalcedonicum,* but in some grains they are moderately distinct. Gelatinization, unlike *L. chalcedonicum,* usually begins at the proximal end and then quickly at one or two points on the distal margin. It proceeds first all along the distal margin, and then from both ends towards the center of the grain. Gelatinization is preceded by a pitted appearance of the surface of the grain and an occasional particle is separated from the ungelatinized material and gelatinized. This does not occur so frequently as in *L. chalcedonicum* and the particles are larger than in that starch. The last part to be gelatinized is that just distal to the hilum and this is gelatinized as is the rest of the grain. The gelatinized grains are as much swollen as in *L. chalcedonicum,* but have thicker capsules and are even more distorted than in that starch.

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 64 per cent of the total starch in 3 minutes; in about 25 per cent of the grains and 77 per cent of the total starch in 5 minutes; in about 70 per cent of the grains and 93 per cent of the total starch in 15 minutes; and in about 98 per cent of the grains and in more than 99 per cent of the total starch in 30 minutes. (Chart D 368.)

The hilum becomes distinct in all the grains, attended by the formation of a bubble in very few of them, as in *L. chalcedonicum.* The lamellæ are moderately distinct, less distinct than in *L. chalcedonicum.* Gelatinization begins at the hilum, which swells more rapidly proximally than distally. As in *L. chalcedonicum,* 2 fissures extend from either side about one-half to three-fourths of the distance from the hilum to the distal margin and the portion included between them is divided by fissures which are neither so distinct nor so irregular and branching as in *L. chalcedonicum.* The starch composing the marginal band is broader at the distal end and shows evidences of a lamellar structure in all parts. The central lamellated portion gelatinizes somewhat more rapidly, leaving a residue of more refractive granules than in *L. chalcedonicum.* The remainder of the reaction is the same as in *L. chalcedonicum.*

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 49 per cent of the total starch in 5 minutes; in about 25 per cent of the grains and 69 per cent of the total starch in 15 minutes; in about 30 per cent of the grains and 78 per cent of the total starch in 30 minutes; in about 42 per cent of the grains and 84 per cent of the total starch in 45 minutes; in about 61 per cent of the grains and 92 per cent of the total starch in 60 minutes. (Chart D 369.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 84 per cent of the entire number of grains and 90 per cent of the total starch in 15 seconds, and in more than 99 per cent of the grains and total starch in 30 seconds. These very large grains are more resistant for a few seconds than those of some other species but are then suddenly completely gelatinized.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 51 per cent of the entire number of grains and 73 per cent of the total starch in 30 seconds; in about 95 per cent of the grains and 97 per cent of the total starch in 1 minute; and in 100 per cent of the grains and total starch in 1 minute and 30 seconds.

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 88 per cent of the entire number of grains and 90 per cent of the total starch in 15 seconds, and in more than 99 per cent of the grains and total starch in 30 seconds. The rare scattered ungelatinized grains may resist the reaction for 5 minutes or longer.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in more than 99 per cent of the entire number of grains and total starch in 10 seconds, and in 100 per cent of the grains and total starch in 15 seconds.

The hilum becomes distinct in all the grains, unattended by the formation of a bubble in any of the grains, as in *L. chalcedonicum.* The lamellæ also are as distinct as in that starch. Gelatinization begins at the hilum, which swells more rapidly and much more in the direction of the proximal than of the distal end. This is not seen in *L. chalcedonicum.* Two fissures extend from either side of the hilum three-fourths of the distance between the hilum and the distal margin. The portion included between them is not so much nor so irregularly fissured as in *L. chalcedonicum.* It gelatinizes more rapidly and is only rarely divided into pyramidal divisions, thus forming a serrated inner border to the distal margin. This is seen in a great majority of the grains of *L. chalcedonicum.* The division by slanting fissures of the portion of the grain just distal to the hilum is also but rarely seen. A granular rather than a spicular residue, as in *L. chalcedonicum,* remains at the distal end of the grain after the gelatinization of this part, and this granular portion is gelatinized more quickly than the residue in *L. chalcedonicum.* The gelatinized grains are as much swollen, have less thick capsules, and are somewhat less distorted than in *L. chalcedonicum.*

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 55 per cent of the entire number of grains and 80 per cent of the total starch in 30 seconds; in about 80 per cent of the grains and 95 per cent of the total starch in 1 minute; in about 97 per cent of the grains and 99 per cent of the total starch in 3 minutes; and in more than 99 per cent of the grains and total starch in 5 minutes.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 50 per cent of the total starch in 15 seconds; in about 60 per cent of the grains and 72 per cent of the total starch in 30 seconds; in 87 per cent of the grains and 96 per cent of the total starch in 1 minute; and in about 97 per cent of the grains and in more than 99 per cent of the grains and total starch in 3 minutes. Rare grains resist complete gelatinization for 5 minutes or longer.

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 88 per cent of the entire number of grains and 93 per cent of the total starch in 15 seconds; in about 99 per cent of the grains and in more than 99 per cent of the total starch in 30 seconds; and in all but rare grains, more than 99 per cent, and total starch in 45 seconds. Very rare grains may remain ungelatinized for 5 minutes or longer.

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 80 per cent of the entire number of grains and 88 per cent of the total starch in 15 seconds, and in about 98 per cent of the grains and in more than 99 per cent of the total starch in 30 seconds. Rare resistant grains may remain ungelatinized for 2 minutes.

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 20 per cent of the entire number of grains and 33 per cent of the total starch in 15 seconds; in about 84 per cent of the grains and 97 per cent of the total starch in 30 seconds; in about 93 per cent of the grains and 99 per cent of the total starch in 45 seconds; and in about 97 per cent of the grains and in more than 99 per cent of the total starch in 60 seconds. Parts of rare resistant grains remain ungelatinized for 5 minutes or longer.

The reaction with *sodium salicylate* begins in 1 minute. Complete gelatinization occurs in about 21 per cent of the entire number of grains and 25 per cent of the total starch in 3 minutes; in 40 per cent of the grains and 45 per cent of the total starch in 5 minutes; in about 89 per cent of the grains and 95 per cent of the total

starch in 10 minutes; and in about 98 per cent of the grains and 99 per cent of the total starch in 15 minutes. (Chart D 370.)

The reaction with *calcium nitrate* begins in a few grains in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 9 per cent of the total starch in 1 minute; in about 36 per cent of the grains and 66 per cent of the total starch in 3 minutes; in about 65 per cent of the grains and 92 per cent of the total starch in 5 minutes; and in about 87 per cent of the grains and 97 per cent of the total starch in 10 minutes.

The reaction with *uranium nitrate* begins in 30 seconds. Complete gelatinization occurs in 1 per cent of the entire number of grains and 16 per cent of the total starch in 1 minute; in about 72 per cent of the grains and 90 per cent of the total starch in 3 minutes; and in about 90 per cent of the grains and 98 per cent of the total starch in 5 minutes.

The reaction with *strontium nitrate* begins in a few grains in 30 seconds. Complete gelatinization occurs in about 8 per cent of the entire number of grains and 16 per cent of the total starch in 1 minute, and in about 95 per cent of the grains and 98 per cent of the total starch in 3 minutes.

The reaction with *cobalt nitrate* begins in a few grains in 15 seconds. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 5 per cent of the total starch in 1 minute; in about 33 per cent of the grains and 60 per cent of the total starch in 3 minutes; in about 56 per cent of the grains and 80 per cent of the total starch in 5 minutes; and in about 90 per cent of the grains and 97 per cent of the total starch in 15 minutes. (Chart D 371.)

The hilum becomes distinct in all the grains, unaccompanied by the formation of a bubble in any. The lamellæ are more distinct than in *L. chalcedonicum.* Gelatinization begins at the hilum, which enlarges more rapidly in the direction of the proximal than toward the distal end. Two fissures, as in *L. chalcedonicum,* extend from either side of the hilum obliquely for three-quarters of the distance between the hilum and the distal margin. The portion included between them is divided by longitudinal and oblique fissures which are more numerous, finer, and less distinct than in *L. chalcedonicum.* As the grain swells these widen and separate and divide the starch into spicules which are gelatinized, leaving a much more indistinctly granular and much smaller residue at the distal end than in *L. chalcedonicum.* Rarely this portion is divided by fissures so that it forms a serrated border as in *L. chalcedonicum.* The marginal starch at the distal and proximal end and at the sides as in *L. chalcedonicum* forms a homogeneous-looking refractive border which gradually grows thinner and more nearly transparent as it is gelatinized. The granular mass at the margin is sometimes gelatinized after (but usually before) the marginal starch, and this process takes place without the great infolding and distention of the capsule seen in *L. chalcedonicum.* The gelatinized grains are as much swollen as in *L. chalcedonicum,* but have somewhat less thick capsules and are not nearly so much distorted at the distal end as in that species.

The reaction with *copper nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 87 per cent of the total starch in 1 minute, and in about 92 per cent of the grains and 98 per cent of the total starch in 3 minutes.

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 8 per cent of the total starch in 1 minute; in about 47 per cent of the grains and 85 per cent of the total starch in 3 minutes; in about 73 per cent of the grains and 95 per cent of the total starch in 5 minutes; and in about 90 per cent of the grains and 99 per cent of the total starch in 10 minutes.

The hilum becomes distinct in all the grains, attended by the formation of a bubble in fewer grains than in *L. chalcedonicum.* The lamellæ are distinct, but not so distinct as in *L. chalcedonicum.* Gelatinization begins at the margin which swells more rapidly toward the proximal than toward the distal end, and this is not accompanied by invagination of the proximal margin as in *L. chalcedonicum.* Two fissures extend from either side of the hilum about three-fourths of the distance from the hilum to the distal margin. The portion included between these fissures is more indistinctly fissured than in *L. chalcedonicum,* it gelatinizes more slowly, and leaves a larger residue at the distal end. This is often not gelatinized until after the marginal material, another point which is different from the procedure in *L. chalcedonicum.* The marginal material forms a thick, refractive, homogeneous band which becomes thinner and more nearly transparent, as in *L. chalcedonicum.* The gelatinized grains are more swollen, have thinner capsules, and are as a rule less distorted than in *L. chalcedonicum.*

The reaction with *barium chloride* begins in a few grains in 45 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 4 per cent of the total starch in 1 minute; in about 23 per cent of the grains and 61 per cent of the total starch in 3 minutes; in about 41 per cent of the grains and 70 per cent of the total starch in 5 minutes; in about 70 per cent of the grains and 90 per cent of the total starch in 15 minutes; and in about 88 per cent of the grains and 96 per cent of the total starch in 30 minutes. (Chart D 372.)

The reaction with *mercuric chloride* begins in about 15 seconds. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 12 per cent of the total starch in 30 seconds; in about 40 per cent of the grains and 76 per cent of the total starch in 1 minute; in about 86 per cent of the grains and 96 per cent of the total starch in 3 minutes; and in about 88 per cent of the grains and 98 per cent of the total starch in 5 minutes.

Lilium testaceum (Hybrid).

(Plate 17, fig. 99; Charts D 367 to D 372.)

Histologic Properties.

In *form* the grains as in both parents are simple and isolated. They are not so regular in form as either parent, in this characteristic more closely resembling *L. chalcedonicum* than *L. candidum.* The irregularities that occur are due to the following causes, the first and second of which are seen in both parents, and the third

only in the hybrid: (1) A large or small rounded protuberance from either side or from the proximal end; (2) small, shallow, depressions and elevations of the distal surface and margin; (3) rarely, to a secondary set of lamellæ, whose longitudinal axis is at an angle with that of the primary set. The conspicuous forms are narrow and broad ovoid, triangular with rounded base and angles, pyriform, and elongated elliptical. The additional forms are irregularly quadrilateral with rounded angles, clam-shell-shaped, curved and straight rod-shaped, and club-shaped. The grains tend to be pointed at the proximal end as in both parents, but less than in *L. chalcedonicum* and somewhat more than in *L. candidum.* The broad grains, as in both parents, are somewhat flattened, and when viewed on edge have an elongated elliptical or ovoid form. In form *L. testaceum* shows a somewhat closer relationship to *L. chalcedonicum* than to *L. candidum.*

The *hilum* is as distinct as in both parents and is rarely fissured as in *L. chalcedonicum.* When present the fissure is always in the form of a small, straight, transversely placed line as in *L. chalcedonicum.* The hilum is eccentric 0.44 to 0.11, usually 0.16, of the longitudinal axis. In the character of the hilum *L. testaceum* shows a somewhat closer relationship to *L. chalcedonicum,* and in the degree of eccentricity to *L. candidum.*

The *lamellæ* are not so distinct and are finer than in either parent, in this respect more closely resembling *L. chalcedonicum.* There is commonly one broad refractive lamella which separates the fine proximal lamellæ from those which are not so fine at the distal end. These latter lamellæ are often wavy and irregular in outline, as in both parents. The number counted on the larger grains varies from 30 to 40, usually 32, distinctly less than in either parent.

In the character and arrangement of the lamellæ *L. testaceum* shows a closer relationship to *L. chalcedonicum* than to *L. candidum.*

In *size* the grains vary from the smaller which are 5 by 5μ, to the larger elongated grains which are 54 by 30μ, and the larger broad grains which are 64 by 58μ, in length and breadth. The common size is 40 by 30μ. In size *L. testaceum* shows a closer relationship to *L. candidum* than to *L. chalcedonicum.*

Polariscopic Properties.

The *figure* is usually as distinct as in both parents, and is as well defined as in *L. candidum.* The lines as in *L. chalcedonicum* rarely cross at right angles and usually at acute angles of varying degree. They are more often bent and bisected than in either parent, and in this respect more closely resemble *L. chalcedonicum* than *L. candidum.* The figure as in *L. chalcedonicum* is sometimes in the form of a conjugate hyperbola, or of a long line bisected at both ends.

The *degree of polarization* varies from low to high (value 60), the same as in *L. chalcedonicum.* There is the same amount of variation in a given aspect of an individual grain as in that starch.

With *selenite* the quadrants are as clear-cut and as unequal in size as in *L. candidum,* but are more irregular in shape than in either parent, and in this respect more closely resemble *L. chalcedonicum.* The colors are often not pure as in *L. chalcedonicum.*

In the character of the figure, the degree of polarization, and the appearances with selenite *L. testaceum* shows a closer relationship to *L. chalcedonicum* than to *L. candidum.*

Iodine Reactions.

With a 0.25 per cent Lugol's solution the grains all color a moderate blue-violet (value 50), less than in either parent but closer to *L. chalcedonicum* than to *L. candidum.* With 0.125 per cent Lugol's solution the grains all color a light to moderate violet tinged with blue, somewhat less than *L. chalcedonicum* and very much less than in *L. candidum.* After heating in water until all the grains are completely gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* all color a moderate or a moderate to deep indigo, and the *solution* a moderate to deep indigo as in *L. chalcedonicum.* If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the *grain-residues* all color a very light or a light indigo, the *capsules* a red or a reddish violet, and the *solution* a very deep indigo, as in *L. chalcedonicum.*

Qualitatively and quantitatively the reaction with iodine shows a closer relationship to *L. chalcedonicum* than to *L. candidum.*

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes they are moderately to very deeply colored (value 80), the same as in *L. candidum* and much more than in *L. chalcedonicum.* They are often more deeply colored at the distal than at the proximal end, as in both parents.

With *safranin* the grains all color very lightly at once, and in 30 minutes they are moderately to very deeply colored (value 80), the same as in *L. candidum* and much more than in *L. chalcedonicum.* As in both parents, the grains are often more deeply colored at the distal than the proximal end.

The reaction with aniline stains shows a closer relationship to *L. candidum* than to *L. chalcedonicum.*

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 61.2° to 63° C., and of all is 65.5° to 67° C.; mean 65.25° C. The temperature of gelatinization of *L. testaceum* is higher than that of either parent, but is closer to that of *L. chalcedonicum* than to *L. candidum.* It is not quite so close to *L. chalcedonicum* as is *L. chalcedonicum* to *L. candidum.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 30 seconds. Complete gelatinization occurs in about 34 per cent of the entire number of grains and 66 per cent of the total starch in 5 minutes; in about 90 per cent of the grains and 96 per cent of the total starch in 15 minutes; and in about 98 per cent of the grains and in more than 99 per cent of the total starch in 30 minutes. (Chart D 367.)

The hilum becomes distinct, attended by the formation of a bubble in as few grains as in *L. chalcedonicum.* The lamellæ as in that starch are never visible. Gelatinization begins at the distal margin and, unlike either parent, proceeds from this point all around the margin,

sometimes more rapidly on one side than on the other. It progresses as in *L. chalcedonicum,* preceded by invasions of the ungelatinized material, by short fissures, and separation of small particles which are then gelatinized. The last portion to be gelatinized is as in both parents that portion immediately distal to the hilum. The gelatinized grains are as much swollen, have as thick capsules, and are as much distorted as in *L. chalcedonicum.* In this reaction *L. testaceum* shows qualitatively a closer relationship to *L. chalcedonicum* than to *L. candidum.*

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 27 per cent of the grains and 77 per cent of the total starch in 3 minutes; in about 33 per cent of the grains and 87 per cent of the total starch in 5 minutes; in about 77 per cent of the grains and 97 per cent of the total starch in 15 minutes; and in about 97 per cent of the grains and in more than 99 per cent of the total starch in 20 minutes. (Chart D 368.)

The hilum becomes distinct in all the grains, attended by the formation of a bubble in many more grains than in either parent. The lamellæ are not so distinct as in either parent, in this respect more closely resembling *L. candidum* than *L. testaceum.* Gelatinization begins at the hilum and progresses as in *L. chalcedonicum.* There are only very slight differences in the methods of gelatinization of the two parents and the hybrid.

In this reaction *L. testaceum* shows qualitatively a somewhat closer relationship to *L. chalcedonicum* than to *L. candidum.*

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 53 per cent of the total starch in 5 minutes; in about 40 per cent of the grains and 86 per cent of the starch in 15 minutes; in about 60 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 70 per cent of the grains and 93 per cent of the total starch in 45 minutes; and in about 73 per cent of the grains and 95 per cent of the total starch in 60 minutes. (Chart D 369.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in more than 99 per cent of the entire number of grains and total starch in 15 seconds. Rare scattered grains may remain ungelatinized for 5 minutes or longer.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 78 per cent of the entire number of grains and 84 per cent of the total starch in 30 seconds, and in about 98 per cent of the grains and 99 per cent of the total starch in 1 minute. Very rare grains may remain for 5 minutes or longer.

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in 100 per cent of the grains and total starch in 15 seconds.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 100 per cent of the entire number of grains and total starch in 10 seconds.

The hilum becomes distinct in all the grains, unattended by the formation of a bubble in any of the grains as in both parents. The lamellæ are also as distinct as in both parents. Gelatinization begins at the hilum and progresses as in *L. chalcedonicum,* except that the fissuring of the portion of the grain included between the 2 fissures which extend from either side of the hilum is less irregular and less distinct than in *L. chalcedonicum.* The starch just distal to the hilum is more often divided by a double row of slanting fissures than in either parent. In this respect the hybrid more closely resembles *L. chalcedonicum.* The rest of the starch is less often divided to form a serrated inner border to the distal margin than in *L. chalcedonicum,* showing the influence of *L. candidum.* The gelatinized grains are more swollen than in either parent. They have rather thin instead of thick capsules, as in both parents, and are not so much distorted as in either parent. These last two characteristics show a closer resemblance to *L. candidum* than to *L. chalcedonicum.*

In this reaction *L. testaceum* shows qualitatively a somewhat closer relationship to *L. chalcedonicum* than to *L. candidum.*

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 70 per cent of the entire number of grains and 93 per cent of the total starch in 30 seconds; in about 89 per cent of the grains and 98 per cent of the total starch in 1 minute; and in about 99 per cent of the grains and in more than 99 per cent of the total starch in 3 minutes. Rare resistant grains remain ungelatinized for 5 minutes or longer.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in 6 per cent of the entire number of grains and 78 per cent of the total starch in 15 seconds; in about 72 per cent of the grains and 91 per cent of the total starch in 30 seconds; in about 89 per cent of the grains and 98 per cent of the total starch in 1 minute; and in 100 per cent of the grains and total starch in 3 minutes.

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 93 per cent of the entire number of grains and 97 per cent of the total starch in 15 seconds, and in more than 99 per cent of the grains and total starch in 20 seconds. Very rare grains may resist gelatinization for 5 minutes or longer.

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 89 per cent of the entire number of grains and 94 per cent of the total starch in 15 seconds, and in more than 99 per cent of the grains and total starch in 30 seconds. Very rare resistant grains may remain ungelatinized for 5 minutes or longer.

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 86 per cent of the entire number of grains and 98 per cent of the total starch in 15 seconds, and in about 98 per cent of the grains and in more than 99 per cent of the total starch in 30 seconds. Parts of very rare resistant grains remain ungelatinized for 5 minutes or longer, but less than in either parent.

The reaction with *sodium salicylate* begins in a few grains immediately. Complete gelatinization occurs in about 51 per cent of the entire number of grains and 67 per cent of the total starch in 3 minutes; in about 78 per cent of the grains and 89 per cent of the total

starch in 5 minutes; in about 97 per cent of the grains and 99 per cent of the total starch in 10 minutes. (Chart D 370.)

The reaction with *calcium nitrate* begins in a few grains in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 8 per cent of the total starch in 1 minute; in about 58 per cent of the grains and 86 per cent of the total starch in 3 minutes; in about 72 per cent of the grains and 95 per cent of the total starch in 5 minutes; and in about 91 per cent of the grains and 98 per cent of the total starch in 10 minutes.

The reaction with *uranium nitrate* begins in 30 seconds. Complete gelatinization occurs in about 39 per cent of the entire number of grains and 50 per cent of the total starch in 1 minute; in about 86 per cent of the grains and 97 per cent of the total starch in 3 minutes; and in about 97 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes.

The reaction with *strontium nitrate* begins in rare grains in 15 seconds. Complete gelatinization occurs in about 43 per cent of the entire number of grains and 63 per cent of the total starch in 1 minute, and in more than 99 per cent of the grains and total starch in 3 minutes.

The reaction with *cobalt nitrate* begins in a few grains in 15 seconds. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 7 per cent of the total starch in 1 minute; in about 47 per cent of the grains and 73 per cent of the total starch in 3 minutes; in about 60 per cent of the grains and 83 per cent of the total starch in 5 minutes; and in about 83 per cent of the grains and 97 per cent of the total starch in 15 minutes. (Chart D 371.)

The hilum becomes distinct in all the grains, accompanied by the formation of a bubble in a few, more than in *L. candidum*, but much less than in *L. chalcedonicum*. The lamellæ are as distinct as in *L. candidum* and more distinct than in *L. chalcedonicum*. Gelatinization begins at the hilum and progresses as in *L. chalcedonicum*, and shows the same exceptions to the method of *L. candidum* as are noted for *L. chalcedonicum* in the description of *L. candidum*. The gelatinized grains are as much swollen and have as thick capsules as in *L. chalcedonicum*, but are somewhat less distinct at the distal end than in that starch, but somewhat more than in *L. candidum*. In this reaction *L. testaceum* shows qualitatively a closer relationship to *L. chalcedonicum* than to *L. candidum*.

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 50 per cent of the entire number of grains and 87 per cent of the total starch in 1 minute, and in more than 99 per cent of the grains and total starch in 3 minutes.

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 10 per cent of the total starch in 1 minute; in about 57 per cent of the grains and 87 per cent of the total starch in 3 minutes; in about 84 per cent of the grains and 97 per cent of the total starch in 5 minutes; and in more than 99 per cent of the grains and total starch in 10 minutes.

The hilum becomes distinct in all the grains, attended by the formation of a bubble in a minority of the grains, as in *L. candidum*. The lamellæ are as distinct as in *L. chalcedonicum*. Gelatinization begins at the hilum and progresses as in *L. chalcedonicum*, except that invagination of the proximal margin is less universal than in that starch, showing the influence of *L. candidum*. The gelatinized grains are as much swollen and have as thick capsules as in *L. chalcedonicum*. They are less distorted than in *L. chalcedonicum*, but somewhat more distorted than in *L. candidum*. In this reaction *L. testaceum* shows qualitatively a somewhat closer relationship to *L. chalcedonicum* than to *L. candidum*.

The reaction with *barium chloride* begins in 30 seconds. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 16 per cent of the total starch in 1 minute; in about 39 per cent of the grains and 67 per cent of the total starch in 3 minutes; in about 46 per cent of the grains and 85 per cent of the total starch in 5 minutes; in about 79 per cent of the grains and 96 per cent of the total starch in 15 minutes; and in about 89 per cent of the grains and 98 per cent of the total starch in 30 minutes. (Chart D 372.)

The reaction with *mercuric chloride* begins in 15 seconds. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 12 per cent of the total starch in 30 seconds; in about 45 per cent of the grains and 71 per cent of the total starch in 1 minute; in about 91 per cent of the grains and 98 per cent of the total starch in 3 minutes; and in about 96 per cent of the grains and 99 per cent of the total starch in 5 minutes.

29. Starches of Lilum pardalinum, L. parryi, and L. burbanki.

Lilium pardalinum (Seed Parent).

(Plate 17, fig. 100; Charts D 373 to D 378.)

Histologic Properties.

In *form* the grains are usually simple and isolated, and only a few compound grains and aggregates are seen. The compound grains belong to but one type: 2 to 4 small grains arranged linearly or in a mass, each consisting of a hilum and 1 or 2 lamellæ and adherent and surrounded by 1 or 2 common secondary lamellæ, with 3 or 4 more discontinuous lamellæ are attached to one side. The aggregates consist of 2 to 4 or more small equal-sized grains arranged linearly or in a mass. There are also a number of large grains which show 3 or 4 shallow, concave, pressure facets at their distal margin, indicating a previous existence as aggregates. The grains are somewhat irregular in form and the irregularities are due to the following causes: (1) A greater development of one part of the distal end than of the rest; (2) protuberances, which may be short or elongated and rounded or pointed, from the proximal end or from the sides; (3) a shifting of the longitudinal axis with a resultant curvature in the middle or near the distal end of the grain; (4) a secondary set of lamellæ whose longitudinal axis forms a right, or an acute, or an obtuse angle with that of the primary set; (5) small elevations and depressions of the distal surface and margin. The conspicuous forms are ovoid with a flattened distal end or with both ends rounded, elongated and broad elliptical with both ends rounded or with a flattened distal end, triangular with curved base and rounded angles, and pyriform. The additional forms are

bottle-shaped, almost round, irregularly quadrilateral with rounded angles, and clam-shell-shaped. The broader forms are somewhat flattened and when seen on edge have an elongated ovoid or elliptical shape.

The *hilum* when it is not fissured is a moderately distinct, round, or lenticular-shaped spot. It is fissured in a majority of the grains and the fissures have the following forms: (1) A small straight or curved horizontal or oblique line which is often somewhat branched; (2) a Y or T figure; (3) an irregularly stellate arrangement of fissures. The hilum is eccentric from 0.4 to 0.09, usually 0.16, of the longitudinal axis.

The *lamellæ* are moderately distinct and fine. Near the hilum they are fine and have the form of a regular, continuous, round, or oval ring. In the rest of the grain they are discontinuous near the distal end and have, in general, the form of the outline of the grain, but are often wavy in outline. There is usually 1 broad refractive lamella situated about two-thirds to three-fourths of the distance from the hilum to the distal margin, which is continuous and which separates the finer proximal lamellæ from those at the distal end which are not so fine. The number of lamellæ counted on the larger grains varies from 24 to 40, commonly 34.

In *size* the grains vary from the smaller which are 6 by 5μ, to the larger broad forms which are 68 by 60μ, rarely 70 by 90μ, to the larger elongated grains which are 66 by 36μ, in length and breadth. The common sizes are 44 by 44μ and 44 by 30μ.

Polariscopic Properties.

The *figure* is distinct, but usually not well defined. The lines are rather thick and tend to be diffused near the margin. They sometimes cross at a right angle, but usually at an acute angle whose size varies somewhat in the different grains. They are usually bent, sometimes very greatly, but are rarely bisected. In some of the figures there is a cross-bar which connects the long arms of the cross about one-half to two-thirds of the distance from the hilum to the margin.

The *degree of polarization* varies from low to high (value 55). In most of the grains it is medium, but in a few low, and in a few high. There is considerable variation in a given aspect of an individual grain.

With *selenite* the quadrants are usually not clear-cut. They are very unequal in size and irregular in shape. The colors are usually pure. They have a greenish tinge in rare grains.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a light to moderate blue-violet (value 40), and the color deepens with moderate rapidity until it is deep and more bluish. With 0.125 per cent Lugol's solution the grains all color a light blue-violet, and the color deepens with moderate rapidity until moderately deep. After heating in water until all the grains are completely gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* all color a deep to a moderate indigo, and the *solution* a moderately deep indigo. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the *grain residues* color a light to moderate indigo-blue, all the *capsules* a very deep violet, and the *solution* a very deep indigo.

Aniline Reactions.

With *gentian violet* the grains all color, very lightly, at once, and in 30 minutes they are moderate to deeply colored (value 65). In most of the grains the distal end is more deeply colored than the rest of the grain.

With *safranin* the grains all color very lightly at once, and in 30 minutes they are moderate to deeply colored (value 65). In most of the grains the distal end is more deeply colored than the rest of the grain.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 58° to 60.5° C., and of all is 61° to 63° C.; the mean is 62° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 30 seconds. Complete gelatinization occurs in about 14 per cent of the entire number of grains and 57 per cent of the total starch in 5 minutes; in about 59 per cent of the grains and 84 per cent of the total starch in 15 minutes; and in about 86 per cent of the grains and 95 per cent of the total starch in 30 minutes. (Chart D 373.)

The hilum becomes distinct, attended by the formation of a bubble in rare grains. The lamellæ are never visible. The grain becomes more refractive, the first portion to show cleavage being a very narrow strip at the margin. Gelatinization begins at the proximal end, followed quickly by the gelatinization of the margin of one side and of the distal end. From here it spreads around the whole margin, only a very narrow strip being gelatinized. Gelatinization progresses inwards, preceded by short fissures which break off particles which are then gelatinized. The last part of the grain to be gelatinized is that just distal to the hilum. The gelatinized grains are much swollen, have thin capsules, and are very much distorted.

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 55 per cent of the entire number of grains and 91 per cent of the total starch in 3 minutes; in about 63 per cent of the grains and 95 per cent of the total starch in 5 minutes; and in about 95 per cent of the grains and in more than 99 per cent of the total starch in 15 minutes. (Chart D 374.)

The hilum becomes distinct in all the grains, attended by the formation of a bubble in rare grains. The lamellæ are moderately distinct. Gelatinization begins at the hilum, which swells lightly, the starch immediately surrounding it being cracked and broken into coarse, refractive granules. Two fissures extend obliquely from either side of the hilum, usually to the distal margin but sometimes only half of the distance between the hilum and the distal margin. The portion included between them becomes indistinctly granular or is seen to be traversed by many indistinct, irregularly branching fissures that divide it into refractive granules which in turn gelatinize rapidly, leaving, however, a fine granular residue that is the last part of the grain to be dissolved. The material at the proximal end and sides, and in some grains at the distal margin, forms a broad, homogeneous-looking refractive band which is dissolved first at one corner of the distal capsule and then separates all the way around from the inner granular portion. This outer portion is dissolved first and then the granular inner portion.

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 43 per cent of the entire number of grains and 82 per cent of the total starch in 5 minutes; in about 82 per cent of the grains and 95 per cent of the total starch in 15 minutes; and in about 90 per cent of the grains and 98 per cent of the total starch in 30 minutes. (Chart D 375.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 99 per cent of the grains and in more than 99 per cent of the total starch in 15 seconds, and in 100 per cent of the grains and total starch in 30 seconds.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 70 per cent of the entire number of grains and 86 per cent of the total starch in 30 seconds; in about 95 per cent of the grains and 99 per cent of the total starch in 1 minute; and in 100 per cent of the grains and total starch in one minute and 30 seconds.

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 90 per cent of the entire number of grains and 95 per cent of the total starch in 15 seconds, and in 100 per cent of the grains and total starch in 30 seconds.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in more than 99 per cent of the grains and total starch in 15 seconds. Rare scattered grains are quite resistant.

The hilum becomes very distinct in all the grains, unattended by the formation of a bubble in any. The lamellæ are very distinct. Gelatinization begins at the hilum. In the eroded grains the starch distal to the hilum is marked by very distinct irregular fissures, which divide it into irregular masses. The lines of cleavage sometimes follow the lines of the lamellæ, but usually do not. This distal deposit is then rapidly gelatinized, first at the distal margin and last near the hilum. The proximal starch is the last to be gelatinized. In the normal grains 2 fissures extend from either side of the hilum a short distance toward the distal margin. The portion included between them and distal to the hilum is divided by fine regular fissures to the margin. As the grain swells some of these open out and so divide this part into regular pyramidal divisions, which form an inner serrated border to the distal margin. This border is gelatinized comparatively rapidly and leaves a granular residue which gelatinizes more slowly, with great infolding and other distortion of the capsule at this point. The gelatinized grains are very much swollen, have rather thin capsules, and are very much distorted especially at the distal end.

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 88 per cent of the entire number of grains and 95 per cent of the total starch in 30 seconds, and in more than 99 per cent of the grains and total starch in 1 minute.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 85 per cent of the entire number of grains and 97 per cent of the total starch in 15 seconds; in about 97 per cent of the grains and 99 per cent of the total starch in 30 seconds; and in 100 per cent of the grains and total starch in 1 minute.

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 97 per cent of the entire number of grains and 99 per cent of the total starch in 15 seconds, and in 100 per cent of the grains and total starch in 25 seconds.

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 90 per cent of the entire number of grains and 98 per cent of the total starch in 15 seconds, and in 100 per cent of the grains and total starch in 30 seconds.

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 93 per cent of the entire number of grains and 98 per cent of the total starch in 15 seconds; in about 98 per cent of the grains and in more than 99 per cent of the total starch in 30 seconds; and in 100 per cent of the grains and total starch in 40 seconds.

The reaction with *sodium salicylate* begins in 30 seconds. Complete gelatinization occurs in about 29 per cent of the entire number of grains and 44 per cent of the total starch in 3 minutes; in about 55 per cent of the grains and 77 per cent of the total starch in 5 minutes; and in about 97 per cent of the grains and 99 per cent of the total starch in 10 minutes. (Chart D 376.)

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 31 per cent of the entire number of grains and 62 per cent of the total starch in 1 minute; in about 80 per cent of the grains and 97 per cent of the total starch in 3 minutes; and in about 98 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes.

The reaction with *uranium nitrate* begins immediately. Complete gelatinization occurs in about 65 per cent of the entire number of grains and 83 per cent of the total starch in 1 minute, and in about 98 per cent of the grains and in more than 99 per cent of the total starch in 3 minutes.

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 65 per cent of the entire number of grains and 80 per cent of the total starch in 1 minute, and in more than 99 per cent of the grains and total starch in 3 minutes.

The reaction with *cobalt nitrate* begins immediately. Complete gelatinization occurs in about 45 per cent of the entire number of grains and 55 per cent of the total starch in 1 minute; in about 80 per cent of the grains and 95 per cent of the total starch in 3 minutes; and in about 97 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 377.)

The hilum becomes distinct in all the grains, attended by the formation of a bubble in a few grains. The lamellæ are moderately distinct. Gelatinization begins at the hilum which swells more toward the proximal than toward the distal end. Two fissures extend from either side of the hilum from one-half to three-fourths of the distance from the hilum to the distal margin, and the portion included between them is divided by fissures. The portion just distal to the hilum is divided into spicules by a double series of fissures which slant proximally from the 2 original fissures to the longitudinal axis of the grain, and is quickly gelatinized. The part between the original fissures is divided by distinct longitudinal, slightly oblique, irregularly branching fissures which, as the grain swells, splits this portion into several

pointed divisions, forming a serrated edge above the unfissured material at the distal margin. Each division is in turn fissured and divided into distinct refractive granules and as gelatinization and swelling proceed the divisions coalesce and form a distinctly granular mass which is very resistant. The deposits at the proximal and distal margins and sides form a homogeneous-looking, refractive band which becomes thinner and more nearly transparent as it gelatinizes. The granular mass at the distal end is the last part of the grain to be gelatinized, and this process occurs with much infolding and irregular distention of the capsule at this point. The gelatinized grains are much swollen, have rather thin capsules, and are greatly distorted, particularly at the distal end.

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 87 per cent of the entire number of grains and 98 per cent of the total starch in 1 minute, and in 100 per cent of the grains and total starch in 3 minutes.

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 33 per cent of the entire number of grains and 60 per cent of the total starch in 1 minute; in about 83 per cent of the grains and 88 per cent of the total starch in 3 minutes; and in about 97 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes.

The hilum becomes distinct in all the grains, attended by the formation of a bubble in very few. The lamellæ are distinct. In eroded grains gelatinization begins at the distal margin, but in normal grains it begins at the hilum. The hilum swells much more rapidly toward the proximal end than toward the distal; indeed, the small amount of material at the proximal end is gelatinized usually before any of the distal material. Two fissures extend obliquely a short distance from either side of the hilum towards the distal margin. The material included between them assumes a pitted appearance and is then broken up into irregular-sized pieces. These are partially gelatinized and the remainder are pushed together into a refractive mass, and as the grain swells this mass is divided into pyramidal divisions, so that it forms a serrated border which often extends all around the inner border of the marginal band, except at the proximal end. This border and the marginal band gelatinize comparatively slowly, with considerable distortion of the capsule. The gelatinized grains are very much swollen, have rather thin capsules, and are greatly distorted, especially at the distal end.

The reaction with *barium chloride* begins in a few grains in 30 seconds. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 10 per cent of the total starch in 1 minute; in about 40 per cent of the grains and 90 per cent of the total starch in 3 minutes; in about 80 per cent of the grains and 96 per cent of the total starch in 5 minutes; and in about 96 per cent of the grains and in more than 99 per cent of the total starch in 15 minutes.

The reaction with *mercuric chloride* begins immediately. Complete gelatinization occurs in about 20 per cent of the entire number of grains and 43 per cent of the total starch in 30 seconds; in about 64 per cent of the grains and 89 per cent of the total starch in 1 minute; and in 100 per cent of the grains and total starch in 3 minutes. (Chart D 378.)

Lilium parryi (Pollen Parent).

(Plate 17, fig. 101; Charts D 373 to D 378.)

Histologic Properties.

In *form* the grains are usually simple and isolated, and compound grains and aggregates are of even less frequent occurrence than in *L. pardalinum.* The compound grains all belong to the same type already described under *L. pardalinum.* The aggregates consist of 2 small equal-sized grains which are adherent at their distal ends. The grains are somewhat less irregular than in *L. pardalinum,* and the irregularities are due to the following causes, which are all seen in *L. pardalinum,* together with one or two other causes: (1) Small, irregular elevations and depressions in the distal end and margin of the grain; (2) a greater development of one part of the distal end than of the rest; (3) low, rounded protuberances from the sides and, rarely, from the proximal end. The conspicuous forms are ovoid, pyriform, and elongated elliptical with rounded or flattened distal end. The additional forms are clam-shell-shaped, lenticular, nearly round, and triangular with curved base and rounded angles. The grains are not so often flattened at the distal end as in *L. pardalinum.* The broad forms, as in *L. pardalinum,* are somewhat flattened and when seen on edge have an ovoid or elliptical shape.

The *hilum* when not fissured is a moderately distinct small, round or lenticular-shaped spot. It is not fissured in a majority of the grains as in *L. pardalinum,* but in a moderate minority. The fissures have the following forms: (1) A single short, straight transverse or slightly oblique line; (2) an irregular stellate arrangement of a number of fissures. The hilum is eccentric from 0.4 to 0.06, usually 0.18, of the longitudinal axis, slightly more than in *L. pardalinum.*

The *lamellæ* are as fine but are not so distinct as those of *L. pardalinum.* There is usually one broad refractive lamella, as in that starch, which is continuous and also situated about two-thirds or three-fourths of the distance from the hilum to the distal margin. This separates the fine proximal lamellæ from those at the distal end which are not so fine. In other characteristics they are the same as in *L. pardalinum.* The number counted on the larger grains varies from 20 to 40, usually 30, somewhat less than in *L. pardalinum.*

In size the grains vary from the smaller which are 6 by 5μ, to the larger elongated grains which are 45 by 34μ, and the larger broad grains which are 40 by 40μ, in length and breadth. The common sizes are 22 by 10μ and 22 by 18μ. The sizes of corresponding types are distinctly less than in *L. pardalinum.*

The *figure* is as distinct and usually somewhat better defined than in *L. pardalinum.* The lines are not so thick and do not tend to become so diffuse near the margin, and they usually cross at a very acute angle and are more often bent than in that starch. There are but few grains in which a cross-bar is seen connecting the two long arms of the cross.

The *degree of polarization* varies from low to high (value 50), less than in *L. pardalinum,* and there are not so many grains in which it is high. There is also not so much variation in a given aspect of an individual grain.

With *selenite* the quadrants are usually more clear-cut, and are unequal in size, and more irregular in shape, than in *L. pardalinum.* The colors are not so often pure as in that starch.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate blue-violet (value 55), much more than in *L. pardalinum,* and the color deepens rapidly until it is very deep and has become distinctly more bluish. With 0.125 per cent Lugol's solution the grains all color lightly to moderately, more than in *L. pardalinum,* and the color deepens with moderate rapidity until it is deep. After heating in water until the grains are all gelatinized, the gelatinized *grains* all color a moderate indigo, less than in *L. pardalinum,* and the *solution* a deep indigo, more than in *L. pardalinum.* If the preparation is boiled for 2 minutes and then treated with a 2 per cent Lugol's solution, the *grain-residues* are usually not colored, except in the capsule; a moderate number are colored a very light indigo, less than in *L. pardalinum;* the *capsules* are all colored a light or moderate violet, less than in *L. pardalinum;* and the *solution* a very deep indigo, more than in *L. pardalinum.*

Aniline Reactions.

With *gentian violet* the grains all color very lightly in 1 minute, and in 30 minutes they are light to moderately colored (value 40), very much less than in *L. pardalinum.* There is no variation in depth of color in different parts of individual grains.

With *safranin* the grains all color very lightly in 1 minute, and in 30 minutes they are light to moderately colored (value 35), very much less than in *L. pardalinum.* There is no variation in depth of color in different parts of individual grains.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 47° to 48.5° C., and of all is 51° to 52° C.; mean 51.5° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 30 seconds. Complete gelatinization occurs in about 40 per cent of the entire number of grains and 70 per cent of the total starch in 5 minutes; in about 90 per cent of the grains and 97 per cent of the total starch in 15 minutes; and in more than 99 per cent of the grains and total starch in 30 minutes. (Chart D 373.)

The hilum becomes distinct, attended by the formation of a bubble in rare grains, and the lamellæ are never visible, as in *L. pardalinum.* The grains become more refractive after the addition of the reagent and the first part to be so affected is a somewhat less narrow strip of starch at the margin than in *L. pardalinum.* Gelatinization begins at the proximal end, as in *L. pardalinum,* but also sometimes at the distal margin; it was not observed in the latter. It proceeds from these points all around the margin and then progresses inward, but is not preceded by fissuring of the ungelatinized starch and breaking off of particles as in *L. pardalinum.* The last part of the grain to be gelatinized is, as in *L. pardalinum,* that just distal to the hilum.

The gelatinized grains are much swollen, have somewhat less thin capsules, and are not so much distorted as in *L. pardalinum.*

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 90 per cent of the entire number of grains and 95 per cent of the total starch in 3 minutes, and in about 92 per cent of the grains and 97 per cent of the total starch in 5 minutes. (Chart D 374.) (Note:—A few grains are moderately resistant and the others very quickly gelatinized, hence not so much difference between the gelatinization of the grains and of the total starch as in most of the other species.)

The hilum, as in *L. pardalinum,* becomes distinct in all the grains, accompanied by the formation of a bubble in a few grains. The lamellæ are moderately distinct, as in *L. pardalinum.* Gelatinization begins at the hilum, which enlarges more rapidly toward the proximal than toward the distal end. Two fissures extend from either side of the hilum about three-fourths of the distance between the hilum and the distal margin. The portion included between them is even more indistinctly fissured than in *L. pardalinum,* and then becomes irregularly granular, the granules being much less refractive than in *L. pardalinum.* The starch at the proximal end and sides forms a homogeneous-looking, refractive band which is sometimes joined to a broad lamellated band at the distal margin, but not so frequently as in *L. pardalinum.* In such grains as in *L. pardalinum,* solution of one part of this distal band is first effected and then the marginal material splits away from the inner granular mass and is dissolved first, the inner granular mass disappearing last. In the majority of the grains, however, this does not occur, but the capsule is dissolved first at the proximal end. Solution extends toward the distal end, the last part to disappear being the distal capsule.

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 84 per cent of the entire number of grains and 98 per cent of the total starch in 5 minutes, and in about 90 per cent of the grains and in more than 99 per cent of the total starch in 15 minutes. (Chart D 375.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 95 per cent of the entire number of grains and 97 per cent of the total starch in 15 seconds; in about 97 per cent of the grains and 98 per cent of the total starch in 30 seconds; and in about 99 per cent of the grains and in more than 99 per cent of the total starch in 1 minute. A few scattered grains are very resistant and may remain ungelatinized for 5 minutes or longer.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 97 per cent of the entire number of grains and 99 per cent of the total starch in 30 seconds, and in about 99 per cent of the grains and in more than 99 per cent of the total starch in 1 minute. Rare grains remain ungelatinized for 5 minutes or longer.

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 99 per cent of the entire number of grains and in more than 99 per cent of the total starch in 15 seconds. The very rare scattered ungelatinized grains may resist the reaction for 5 minutes or longer.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in more than 99

per cent of the grains and total starch in 15 seconds. Rare scattered grains are quite resistant.

The hilum becomes distinct in all of the grains, attended by the formation of a bubble in a moderate number. This is not seen in *L. pardalinum.* The lamellæ are somewhat less distinct than in *L. pardalinum.* Gelatinization begins at the hilum, which swells very rapidly, more rapidly toward the proximal than toward the distal end of the grain. Two fissures extend from either side of the hilum three-fourths of the distance between the hilum and the distal margin. The portion included between these 2 fissures is fissured more distinctly and irregularly than is a similar portion in the normal grains of *L. pardalinum.* This part of the grain is gelatinized very rapidly, leaving a residue of very distinct granules which are much more refractive than similar granules in *L. pardalinum.* This gelatinizes with much infolding and other distortion of the capsule at this point. The portion at the proximal margin and sides forms a refractive, homogeneous-looking band which gradually grows thinner and more nearly transparent until it is gelatinized and only the capsule remains. The gelatinized grains are as much swollen, have thinner capsules, and are more distorted than in *L. pardalinum.*

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 94 per cent of the entire number of grains and 97 per cent of the total starch in 30 seconds; in about 95 per cent of the grains and 98 per cent of the total starch in 1 minute; in about the same percentage of grains and total starch in 3 minutes; and in about 96 per cent of the grains and 99 per cent of the total starch in 5 minutes.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 93 per cent of the entire number of grains and 96 per cent of the total starch in 15 seconds, and in about 96 per cent of the grains and 98 per cent of the total starch in 30 seconds. Rare grains remain ungelatinized for 5 minutes or longer.

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 96 per cent of the entire number of grains and in more than 99 per cent of the total starch in 10 seconds. Very rare grains resist gelatinization for 5 minutes or longer.

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in more than 99 per cent of the grains and total starch in 10 seconds. Rare resistant grains remain ungelatinized for 5 minutes or longer.

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 95 per cent of the entire number of grains and 98 per cent of the total starch in 15 seconds, and in about 98 per cent of the grains and 99 per cent of the total starch in 30 seconds. Rare resistant grains remain ungelatinized for 5 minutes or longer.

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 67 per cent of the entire number of grains and 82 per cent of the total starch in 3 minutes; in about 85 per cent of the grains and 95 per cent of the total starch in 5 minutes; and in about 98 per cent of the grains and 99 per cent of the total starch in 10 minutes. (Chart D 376.)

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 76 per cent of the entire number of grains and 95 per cent of the total starch in 1 minute; in about 95 per cent of the grains and 97 per cent of the total starch in 3 minutes; and in about 97 per cent of the grains and 98 per cent of the total starch in 5 minutes.

The reaction with *uranium nitrate* begins immediately. Complete gelatinization occurs in about 95 per cent of the entire number of grains and 97 per cent of the total starch in 1 minute, and in more than 99 per cent of the grains and total starch in 3 minutes.

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 95 per cent of the entire number of grains and 96 per cent of the total starch in 1 minute, and in more than 99 per cent of the grains and total starch in 3 minutes.

The reaction with *cobalt nitrate* begins immediately. Complete gelatinization occurs in about 92 per cent of the entire number of grains and 95 per cent of the total starch in 1 minute; in about 96 per cent of the grains and 99 per cent of the total starch in 3 minutes; and in about 98 per cent of the grains and 99 per cent of the total starch in 5 minutes. (Chart D 377.)

The hilum becomes distinct in all the grains, attended by the formation of a bubble in about half of the grains, more than in *L. pardalinum.* The lamellæ are moderately distinct, as in *L. pardalinum.* Gelatinization begins at the hilum, which swells more toward the proximal than toward the distal end. Two fissures proceed slightly obliquely from either side of the hilum three-fourths of the distance from the hilum to the distal margin. The portion between these 2 fissures is in turn fissured, but the fissures are not so distinct nor so branched as in *L. pardalinum.* As the grain swells these fissures widen and divide the starch into irregular pointed masses which form a serrated border to the marginal deposit at the distal end. This is unaccompanied by the formation of slanting fissures and division into spicules of the starch just distal to the hilum, such as is seen in *L. pardalinum.* As gelatinization progresses and the grain continues to swell, this serrated border coalesces and forms an irregularly granular mass, at the distal end of which the granules are neither as distinct nor as refractive as in *L. pardalinum.* The portion at the proximal and distal margins and sides, as in *L. pardalinum,* forms a homogeneous-looking refractive band which slowly grows thinner and more transparent as it is gelatinized. The granular starch at the distal end is the last part of the grain to be gelatinized, and this process takes place with much infolding and distention of the capsule at that point. The gelatinized grains are very much swollen, have somewhat thinner capsules than in *L. pardalinum,* and are very much distorted at the distal end, but not so much as in *L. pardalinum.*

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 95 per cent of the entire number of grains and 98 per cent of the total starch in 1 minute, and in about 97 per cent of the grains and 99 per cent of the total starch in 3 minutes.

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 89 per cent of the entire number of grains and 97 per cent of the total starch in 1 minute; in about 99 per cent of the grains

and total starch in 3 minutes; and in about the same percentage of the grains and total starch in 5 minutes.

The hilum becomes distinct in all the grains, attended by the formation of a bubble in very few, as in *L. pardalinum.* The lamellæ are usually not very distinct, not nearly so distinct as in *L. pardalinum.* Gelatinization begins at the hilum, which swells more rapidly toward the proximal than the distal end. Two fissures extend from either side of the hilum about three-fourths of the distance between the hilum and the distal margin further than in *L. pardalinum.* The portion included between these fissures is broken up into refractive granules which gelatinize more readily than similar granules of *L. pardalinum.* They leave a residue of very refractive granules at the distal end of the grain, which is gelatinized usually before the marginal starch. This is never split to form a serrated border, as in *L. pardalinum.* The material at the proximal and distal margins and sides forms a refractive, homogeneous-looking band which gelatinizes comparatively slowly. The gelatinized grains are as much swollen as in *L. pardalinum.* They have not such thick capsules and are not so much distorted as in that starch.

The reaction with *barium chloride* begins immediately. Complete gelatinization occurs in about 65 per cent of the entire number of grains and 91 per cent of the total starch in 1 minute; in about 96 per cent of the grains and 98 per cent of the total starch in 3 minutes; and in about 97 per cent of the grains and 99 per cent of the total starch in 5 minutes.

The reaction with *mercuric chloride* begins immediately. Complete gelatinization occurs in about 93 per cent of the entire number of grains and 95 per cent of the total starch in 30 seconds; in about 96 per cent of the grains and 99 per cent of the total starch in 1 minute; and in about 98 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 378.)

Lilium burbanki (Hybrid).

(Plate 17, fig. 102; Charts D 373 to D 378.)

Histologic Properties.

In *form* the grains are always simple and usually isolated. No compound grains are seen, although they occur in both parents, but there is a small number of aggregates as in *L. parryi,* and, as in that starch, are composed of two components of equal size adherent to one another at their distal ends. The grains are more regular in form than in either parent, in this characteristic more closely resembling *L. pardalinum.* The irregularities that occur are due to the following causes which are seen in both parents: (1) Small rounded or large, pointed protuberances from the proximal end or from the sides; (2) a greater development of one part of the distal end than of the rest. The conspicuous forms are broad ovoid and pure ovoid, triangular with curved base and rounded angles, elliptical, and pyriform. The additional forms are nearly round, clam-shell-shaped, and lenticular. As in both parents, the broader forms are somewhat flattened, and when viewed on edge have an elongated ovoid or elliptical form. In form *L. burbanki* shows a somewhat closer relationship to *L. pardalinum* than to *L. parryi.*

The *hilum* is not so distinct and is less often fissured than in either parent, and in this respect shows a closer relationship to *L. parryi* than to *L. pardalinum.* The fissures when present have the same forms as in *L. parryi.* The hilum is eccentric from 0.43 to 0.14, usually 0.2, of the longitudinal axis. It is less eccentric than in either parent.

In the character and eccentricity of the hilum, *L. burbanki* shows a closer relationship to *L. parryi* than to *L. pardalinum.*

The *lamellæ* are as fine and as distinct as in *L. pardalinum* and have the same characteristics as in that starch, except that they do not at any time have a wavy or irregular outline. The lamellæ counted on the larger grains vary from 22 to 35, usually 28.

In *size* the grains vary from the smaller which are 6 by 6μ, to the large broad forms which are 50 by 46μ, and the larger elongated forms which are 48 by 30μ, in length and breadth. The common sizes are 34 by 30μ and 34 by 24μ.

In size *L. burbanki* is somewhat closer to *L. pardalinum* than to *L. parryi,* but shows almost a mid-degree of intermediateness between the two parents.

Polariscopic Properties.

The *figure* is as distinct as in both parents and is better defined than in either parent, in this respect more closely resembling *L. parryi* than *L. pardalinum.* The lines usually cross at a very acute angle as in *L. parryi,* but they are not so often bent as in either parent, and in this respect more nearly resemble *L. pardalinum.* The figure, less often than in either parent, has a variation in the form of a cross-bar connecting the two longer arms of the cross, and in this respect more nearly resembles *L. parryi.*

The *degree of polarization* varies from low to high (value 50), the same as in *L. parryi.* There is little variation in a given aspect of an individual grain.

With *selenite* the quadrants are more clear-cut than in either parent, and in this respect are closer to *L. parryi.* They are less unequal in size and irregular in shape than in either parent, and in this respect are closer to *L. pardalinum.* The colors are usually not pure as in *L. parryi.*

In the degree of polarization, the character of the figure, and the appearances with selenite *L. burbanki* shows a closer relationship to *L. parryi* than to *L. pardalinum.*

Iodine Reactions.

With 0.25 per cent Lugol's solution, the grains all color a light to moderate blue-violet (value 40), the same as in *L. pardalinum* and less than in *L. parryi.* With 0.125 per cent Lugol's solution the grains all color lightly, the same as in *L. pardalinum.* If the grains are heated in water until all are completely gelatinized and then treated with a 2 per cent Lugol's solution, the gelatinized *grains* are very deeply or deeply colored indigo, more than in either parent but closer to *L. pardalinum,* and the *solution* colored a moderate indigo, less than in either parent. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the *grain-residues* nearly all color a light to moderate indigo, more than in either parent; the *capsules* a very deep violet, as in *L. pardalinum;* and the *solution* a very deep indigo, as in *L. pardalinum.*

Qualitatively and quantitatively the reactions with iodine show a closer relationship to *L. pardalinum* than to *L. parryi.*

Aniline Reactions.

With *gentian violet* the grains all color, very lightly, in 1 minute, and in 30 minutes they are moderately colored (value 45), more than *L. parryi* but much less than *L. pardalinum.*

With *safranin* the grains all color very lightly in 1 minute, and in 30 minutes they are lightly to moderately colored (value 40), more than in *L. parryi,* but much less than in *L. pardalinum.*

In the reaction with aniline stains *L. burbanki* shows a closer relationship to *L. parryi* than to *L. pardalinum.*

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 64° to 66° C., and of all is 67° to 68.5° C.; the mean is 67.75° C. The temperature of gelatinization of *L. burbanki* is higher than that of either parent, but is closer to *L. pardalinum* than to *L. parryi.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 30 seconds. Complete gelatinization occurs in about 30 per cent of the entire number of grains and 60 per cent of the total starch in 5 minutes; in about 80 per cent of the grains and 88 per cent of the total starch in 15 minutes; in about 98 per cent of the grains and 99 per cent of the total starch in 30 minutes. (Chart D 373.)

The hilum, as in both parents, rarely becomes distinct and attended by the formation of a bubble. The lamellæ, as in the parents, are invisible. The grains become more refractive; the first part to show this change is a narrow strip of starch at the margin which is as narrow and as refractive as in *L. parryi.* Gelatinization begins at the proximal end, as in *L. pardalinum,* and progresses in the majority of the grains as in that starch. In a minority, however, it proceeds the same as in *L. parryi.* The gelatinized grains are as much swollen, have as thin capsules, and are as much distorted as in *L. pardalinum.*

In this reaction *L. burbanki* shows qualitatively a closer relationship to *L. pardalinum* than to *L. parryi.*

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 22 per cent of the entire number of grains and 55 per cent of the total starch in 3 minutes; in about 29 per cent of the grains and 62 per cent of the total starch in 5 minutes; in about 50 per cent of the grains and 80 per cent of the total starch in 15 minutes; in about 70 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 80 per cent of the grains and 95 per cent of the total starch in 45 minutes; and in about 93 per cent of the grains and 99 per cent of the total starch in 60 minutes. (Chart D 374.) (This has been repeated and found to go quite as slow or even slightly slower.)

The hilum becomes distinct in all the grains, unattended by the formation of a bubble in any. The lamellæ are usually less distinct than in the parents, which show the same degree of distinctness. Gelatinization begins at the hilum and progresses in the great majority of the grains as in *L. pardalinum,* with the single exception that fissuring and granulation are more distinct than in that starch. In a small minority the process is the same as that described for the majority of the grains of *L. parryi.* In this reaction *L. burbanki* shows qualitatively a somewhat closer relationship to *L. pardalinum* than to *L. parryi.*

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 8 per cent of the entire number of grains and 57 per cent of the total starch in 5 minutes; in about 16 per cent of the grains and 71 per cent of the total starch in 15 minutes; in about 25 per cent of the grains and 80 per cent of the total starch in 30 minutes; in about 43 per cent of the grains and 83 per cent of the total starch in 45 minutes; and in about 54 per cent of the grains and 86 per cent of the total starch in 60 minutes. (Chart D 375.) The grains of this starch are quite resistant. The capsule after gelatinization is very little if any distorted, which is not usually found in the Liliaceæ.

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 93 per cent of the entire number of grains and 90 per cent of the total starch in 15 seconds; in about 95 per cent of the grains and 97 per cent of the total starch in 30 seconds; and in about 98 per cent of the grains and 99 per cent of the total starch in 1 minute. A few grains are quite resistant and remain ungelatinized for 5 minutes and longer.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 88 per cent of the entire number of grains and 96 per cent of the total starch in 30 seconds, and in about 98 per cent of the grains and 99 per cent of the total starch in 1 minute. Rare grains may remain ungelatinized for 5 minutes or longer.

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 88 per cent of the entire number of grains and 92 per cent of the total starch in 15 seconds, and in about 98 per cent of the grains and 99 per cent of the total starch in 30 seconds. The rare scattered grains resist gelatinization for 5 minutes or longer.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in more than 99 per cent of the entire number of grains and total starch in 15 seconds. Very rare grains are quite resistant.

The hilum becomes distinct in all the grains, unattended by the formation of a bubble in any as in *L. pardalinum.* The lamellæ are as distinct as in *L. pardalinum.* Gelatinization begins at the hilum and progresses as in the normal grain of *L. pardalinum.* The gelatinized grains are as much swollen and have as thin capsule as in *L. pardalinum.* They are somewhat less distorted than in *L. pardalinum* and considerably less than in *L. parryi.*

In this reaction *L. burbanki* shows qualitatively a closer relationship to *L. pardalinum* than to *L. parryi.*

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 42 per cent of the entire number of grains and 86 per cent of the total starch in 30 seconds; in about 66 per cent of the grains and 91 per cent of the total starch in 1 minute; in about 84 per cent of the grains and 98 per cent of the total starch in 3 minutes; and in about 93 per cent of the grains and 99 per cent of the total starch in 5 minutes.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 30 per cent of the entire number of grains and 66 per cent of the total starch in 15 seconds; in about 60 per cent of the grains and 90 per cent of the total starch in 30 seconds; in about 80 per cent of the grains and 95 per cent of the total starch in 1 minute; and in about 93 per cent of the grains and 98 per cent of the total starch in 3 minutes. Resistant grains remain ungelatinized at 5 minutes and longer.

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 90 per cent of the entire number of grains and 94 per cent of the total starch in 15 seconds, and in about 99 per cent of the grains and in more than 99 per cent of the total starch in 30 seconds. Rare grains resist gelatinization for 5 minutes or longer.

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 75 per cent of the entire number of grains and 90 per cent of the total starch in 15 seconds; in about 93 per cent of the grains and 98 per cent of the total starch in 30 seconds; and in more than 99 per cent of the grains and total starch in 60 seconds. Rare resistant grains remain ungelatinized for 5 minutes and longer.

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 81 per cent of the entire number of grains and 90 per cent of the total starch in 15 seconds; in about 88 per cent of the grains and 95 per cent of the total starch in 30 seconds; in about 95 per cent of the grains and 99 per cent of the total starch in 45 seconds; and in more than 99 per cent of the grains and total starch in 60 seconds. Rare resistant grains remain ungelatinized for 5 minutes or longer; a larger number remains than in either parent.

The reaction with *sodium salicylate* begins in 30 seconds. Complete gelatinization occurs in about 55 per cent of the entire number of grains and 70 per cent of the total starch in 3 minutes; in about 90 per cent of the grains and 96 per cent of the total starch in 5 minutes; and in about 99 per cent of the grains and in more than 99 per cent of the total starch in 10 minutes. (Chart D 376.)

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 48 per cent of the grains and 64 per cent of the total starch in 1 minute; in about 80 per cent of the grains and 95 per cent of the total starch in 3 minutes; and in about 92 per cent of the grains and 99 per cent of the total starch in 5 minutes.

The reaction with *uranium nitrate* begins in 15 seconds. Complete gelatinization occurs in about 26 per cent of the entire number of grains and 38 per cent of the total starch in 1 minute; in about 70 per cent of the grains and 90 per cent of the total starch in 3 minutes; and in about 86 per cent of the grains and 98 per cent of the total starch in 5 minutes.

The reaction with *strontium nitrate* begins in 15 seconds. Complete gelatinization occurs in about 45 per cent of the entire number of grains and 56 per cent of the total starch in 1 minute, and in about 96 per cent of the grains and 99 per cent of the total starch in 3 minutes.

The reaction with *cobalt nitrate* begins in a few grains in 30 seconds. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 7 per cent of the total starch in 1 minute; in about 40 per cent of the grains and 60 per cent of the total starch in 3 minutes; in about 47 per cent of the grains and 80 per cent of the total starch in 5 minutes; in about 73 per cent of the grains and 90 per cent of the total starch in 15 minutes; and in about 90 per cent of the grains and 95 per cent of the total starch in 30 minutes. (Chart D 377.)

The hilum becomes distinct in all the grains, attended by the formation of a bubble in but few grains, as in *L. pardalinum.* The lamellæ are moderately distinct as in both parents. Gelatinization begins at the hilum and progresses as in *L. pardalinum,* except that at first the fissures dividing the portion included between the 2 original fissures from the hilum are even finer and less distinct than in *L. parryi,* but later they have the same appearance as in *L. pardalinum.* The gelatinized grains are as much swollen and have as thin capsules as in *L. parryi.* They are as much distorted, particularly at the distal end, as in *L. pardalinum,* and more than in *L. parryi.*

In this reaction *L. burbanki* shows qualitatively a somewhat closer relationship to *L. pardalinum* than to *L. parryi.*

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 48 per cent of the entire number of grains and 79 per cent of the total starch in 1 minute, and in about 91 per cent of the grains and 97 per cent of the total starch in 3 minutes.

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 12 per cent of the total starch in 1 minute; in about 54 per cent of the grains and 85 per cent of the total starch in 3 minutes; in about 66 per cent of the grains and 92 per cent of the total starch in 5 minutes; in about 89 per cent of the grains and 97 per cent of the total starch in 10 minutes; and in about 95 per cent of the grains and in more than 99 per cent of the total starch in 15 minutes.

The hilum becomes distinct in all the grains, attended by the formation of a bubble in very few grains, as in both parents. The lamellæ are as distinct as in *L. pardalinum.* Gelatinization begins at the hilum and progresses as in *L. pardalinum,* except that there is somewhat more definite fissuring and granule formation, showing the influence of *L. parryi.* The gelatinized grains are as much swollen as in both parents, have as thin capsules as in *L. parryi,* and are more distorted than in *L. parryi* and somewhat less than in *L. pardalinum.*

In this reaction *L. burbanki* shows qualitatively a somewhat closer relationship to *L. pardalinum* than to *L. parryi.*

The reaction with *barium chloride* begins in a few grains in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 5 per cent of the total starch in 1 minute; in about 49 per cent of the grains and 66 per cent of the total starch in 3 minutes; in about 52 per cent of the grains and 79 per cent of the total starch in 5 minutes; in about 79 per cent of the grains and 93 per cent of the total

starch in 15 minutes; and in about 80 per cent of the grains and 95 per cent of the total starch in 30 minutes.

The reaction with *mercuric chloride* begins in a few grains in 15 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 30 seconds; in about 27 per cent of the grains and 50 per cent of the total starch in 1 minute; in about 55 per cent of the grains and 88 per cent of the total starch in 3 minutes; in about 73 per cent of the grains and 90 per cent of the total starch in 5 minutes; and in about 88 per cent of the grains and 98 per cent of the total starch in 15 minutes. (Chart D378.)

8. IRIS.

This genus includes about 175 recognized species, a very large number of garden varieties, and many hybrids. Apart from the recognized horticultural groups (German, Japanese, Dwarf, and Oncocyclus Irises), these plants are divided into two series which are distinguished by a thick root-stock or creeping rhizome, and by a bulbous root-stock, respectively. Hasselbring includes in the first series the subgenera *Apagon, Pardanthopsis, Evansia, Pseudovansia, Pogoniris* and *Regelia,* and *Ocnocyclus;* and in the second series, *Xiphion, Gynandiris,* and *Juno.* In this research studies were made of the starches of the following species and hybrids: *I. iberica* Hoffm., *I. trojana* Kerner, *I. cengialti* Ambrosi, *I. pallida queen of may* Hort., *I. persica* var. *purpurea* Hort., and *I. sindjarensis* Boiss. and Haussk.; and the hybrids *I. ismali, I. dorak, I. mrs. alan grey,* and *I. pursind.* The first four of the parents belong to the rhizomatous series, and the last two to the bulbous series. All of the specimens were obtained from Barr and Sons, London.

30. *I. iberica* (seed parent), *I. trojana* (pollen parent), and *I. ismali* (hybrid), page 636.
31. *I. iberica* (seed parent), *I. cengialti* (pollen parent), and *I. dorak* (hybrid), page 647.
32. *I. cengialti* (seed parent), *I. pallida queen of may* (pollen parent), and *I. mrs. alan grey* (hybrid), page 656.
33. *I. persica* var. *purpurea* (seed parent), *I. sindjarensis* (pollen parent), and *I. pursind* (hybrid), page 664.

In the first set, the cross was between members of the subgenera *Oncocyclus* and *Apagon;* in the second, between members of the subgenera *Oncocyclus* and *Pogoniris* and *Regelia;* in the third, between members of the subgenus *Pogoniris* and *Regelia;* and in the fourth, between members of the subgenus *Juno* (in the first three between rhizomatous irids; and in the last, between bulbous forms).

30. Starches of Iris iberica, I. trojana, and I. ismali.

Iris iberica (Seed Parent).

(Plate 18, figs. 103 and 106; Charts D 379 to D 399.)

Histologic Properties.

In *form* the grains are usually simple and isolated, though a moderate number of small aggregates of 2 or, rarely, 3 components are noted, and a few compound grains, which are of two types. The first type consists of 2 small grains, each consisting of a hilum and 1 or 2 lamellæ and surrounded by 8 to 15 common secondary lamellæ and attached to the proximal end of a large elongated grain. The second type consists of 2 or 3 small grains, if 3 they are pyramidally arranged, each consisting of 4 or 5 lamellæ and surrounded by 1 or 2 common secondary lamellæ. The grains are usually moderately regular in form, and any irregularities which occur are due to the following causes, in order of frequency of occurrence: (1) Secondary sets of lamellæ whose longitudinal axis is at an angle, usually a right angle with that of the primary set; (2) large flattened and rounded protuberances from the sides or from either end; (3) deviation of the longitudinal axis with consequent bending of the grain, usually at the distal end, or middle; (4) sharply defined, triangular depressions in the margin at the side, probably representing pressure facets; (5) shallow, rounded depressions and elevations of the surface, giving a wavy or undulating outline to the margin; (6) rarely, a small, rather narrow, sharply defined notch in the center of the distal margin. The conspicuous forms are elongated elliptical, usually with a flattened distal end, and sometimes with a set of secondary lamellæ from one side causing a modification of form, and ovoid, with or without a flattened distal end. The additional forms are round and nearly round, reniform, pyriform, club-shaped, boot-shaped, napiform, triangular with rounded angles, and short T-shape. The grains are not flattened.

The *hilum* is a moderately distinct, round spot and not often fissured. When fissures occur they have the following forms: (1) A small, short, straight, transverse, oblique, or, rarely, longitudinal line; (2) like a flying-bird. Not infrequently 2 refractive fissures are seen extending from either side of the hilum, and appear to be in the inner substance of the grain, and do not come to the surface. The hilum is eccentric from 0.25 to 0.08, usually 0.15, of the longitudinal axis.

The *lamellæ* are usually rather coarse and not very distinct, but they may be demonstrated on many of the grains. They are continuous and circular in form near the hilum and in the rest of the grain they usually appear discontinuous and follow in general the form of the outline of the grain. They often show some irregularities, the chief of which is a small notch or depression corresponding to the notch in the distal margin before noted, but this does not always occur in the same grain. There is, frequently, one very coarse, rather refractive lamellæ which is placed at either half the distance between the hilum and the distal margin, or very near the distal margin. The number of lamellæ counted on the larger grains varies from 8 to 18, usually 12.

In *size* the smaller grains vary from 4 by 4μ to the larger which are 34 by 16μ and 32 by 17μ, in length and breadth. The common size is 20 by 14μ.

Polariscopic Properties.

The *figure* is very distinct and well defined. The lines usually cross at an acute angle which varies considerably in different grains, but sometimes they cross at a right angle. They are often considerably bent, but rarely bisected.

The *degree of polarization* varies from low to high (value 50). In a few grains it is low, in very few high,

and in most it is moderate or moderately high. In some it is lower between the two limbs of the cross than elsewhere.

With *selenite* the quadrants are usually clear-cut. They are unequal in size and often irregular in form. The colors are usually not pure.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a light to moderate violet tinged with blue (value 40). The color deepens moderately rapidly until very deep and more bluish. With 0.125 per cent Lugol's solution the grains all color a light violet and the color deepens rather slowly until moderately deep and more bluish. After heating in water until all the grains are completely gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* are colored a deep or a moderately deep indigo, and the *solution* a deep indigo. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent of Lugol's solution, most of the *grain-residues* show only an empty capsule, but in a very few the contents are colored a very light indigo; the *capsules* a deep wine-red; and the *solution* a very deep indigo.

Aniline Reactions.

With *gentian violet,* the grains stain very lightly at once, and in 30 minutes they are light to moderately stained (value 40). Some grains are moderately stained and some lightly, and the rest light to moderately. There is no unevenness of coloring noted on the individual grains.

With *safranin* the grains stain very lightly at once, and in 30 minutes they are moderately stained (value 45). There are more moderately and moderate to lightly stained grains than in gentian violet.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 69° to 70° C., and of all is 71° to 72.5° C., mean 71.75° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 1 minute. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 32 per cent of the grains and 39 per cent of the total starch in 15 minutes; in about 45 per cent of the grains and 50 per cent of the total starch in 30 minutes; in about 54 per cent of the grains and 60 per cent of the total starch in 45 minutes; and 60 per cent of the grains and 64 per cent of the total starch in 60 minutes. (Chart D 379.)

The hilum becomes distinct, attended in most grains by the formation of a small bubble, which persists until the hilum is reached in the process of gelatinization. The lamellæ are always rather indistinct, and become obliterated as gelatinization progresses. The whole grain becomes somewhat refractive, the first part of the grain to show this is a broad band around the margin. Gelatinization begins at the distal corners of the grain just above the margin. Two refractive cracks or fissures are seen to separate the marginal portion at these points from the rest of the grain and the marginal starch is then gelatinized with considerable swelling and distortion of the capsule. Then the rest of the distal deposit assumes a pitted appearance and is invaded on either side by a longitudinal refractive fissure which extends about two-thirds of the way to the proximal end. Between these two fissures the starch becomes more and more refractive, and is invaded in the interior but not on the surface by several longitudinal refractive fissures, and then divided by granules from these fissures into granules of varying sizes and shapes. In the meantime gelatinization has spread from the corners of the distal end all along the distal margin and now extends toward the proximal end, and the granules which have been previously formed are separated off and gelatinized. The reaction proceeds more rapidly in the interior of the grain than on the surface, which is proved by the fact that before the hilum is reached on the surface, a refractive canal or fissure is formed to the hilum in the central part of the grain, the bubble swells and lengthens out into this canal and sometimes passes through it distally before shrinking and then disappearing, the hilum enlarges considerably, and the surface and marginal material is at the same time rapidly gelatinized except at the proximal margin, which is the last to be broken down, and is often very resistant, remaining for a long time after the rest of the grain is completely gelatinized. In a very few grains the proximal end is gelatinized after gelatinization has progressed about half-way between the distal end and the hilum, the most resistant part in such cases being just distal to the hilum.

The gelatinized grains are much swollen, have rather thin capsules, and are very much distorted especially at the distal end, and they retain very little resemblance to the form of the untreated grain.

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 70 per cent of the total starch in 15 minutes; in about 24 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 52 per cent of the grains and 97 per cent of the total starch in 45 minutes; in about 79 per cent of the grains and 99 per cent of the total starch in 60 minutes. (Chart D 380.)

The reactions with chromic acid are difficult to obtain with any degree of satisfaction as in other species of irids. The grains have a tendency to collect in groups (as in many other species) and bubbles appear (as found in many other species). These bubbles may either expand or collapse, causing the grains in the field under observation to move from the field or crowd together. Since there is always a tendency to some solution of the grains with chromic acid, when a new field must be sought at 30 minutes, as the result of movement from collapse of bubbles, etc.; it is impossible to compute the number of grains with perfect accuracy since it is impossible to determine what proportion has been dissolved. The wall of some grains is very resistant, a small amount remaining ungelatinized; this may extend largely around the margin or only at the proximal end and sides.

Gelatinization begins rather slowly, and then the process advances in most of the grains with considerable rapidity, only a small amount of ungelatinized material remaining in a few grains.

The results obtained with this reagent are very conflicting unless studied in clear weather as the solution tends to darken the field so that the final stages are difficult to ascertain.

The reaction with *pyrogallic acid* begins in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 22 per cent of the total starch in 5 minutes; in about 30 per cent of the grains and 72 per cent of the total starch in 15 minutes; in about 42 per cent of the grains and 81 per cent of the total starch in 30 minutes; in about 53 per cent of the grains and 86 per cent of the total starch in 45 minutes; in about 54 per cent of the grains and 90 per cent of the total starch in 60 minutes. (Chart D 381.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 24 per cent of the entire number of grains and 58 per cent of the total starch in 5 minutes; in about 33 per cent of the grains and 73 per cent of the total starch in 15 minutes; in about 40 per cent of the grains and 77 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 81 per cent of the total starch in 45 minutes; in about 44 per cent of the grains and 84 per cent of the total starch in 60 minutes. (Chart D 382.)

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 62 per cent of the entire number of grains and 85 per cent of the total starch in 2 minutes; in about 89 per cent of the grains and 99 per cent of the total starch in 5 minutes. (Chart D 383.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 15 per cent of the entire number of grains and 53 per cent of the total starch in 5 minutes; in about 36 per cent of the grains and 63 per cent of the total starch in 15 minutes; in about 45 per cent of the grains and 72 per cent of the total starch in 30 minutes; in about 50 per cent of the grains and 81 per cent of the total starch in 45 minutes; in about 59 per cent of the grains and 86 per cent of the total starch in 60 minutes. (Chart D 384.)

The hilum becomes very distinct, unattended by the formation of a bubble. The lamellæ also are distinct, but later become obscured. Gelatinization begins at the hilum and is preceded by an extension and widening of 2 refractive lines or fissures which, in the untreated grain, extend distally in the interior of the grain from either side of the hilum. The starch included between these fissures and the hilum and the distal margin becomes more refractive in appearance and is divided into fine granules which are arranged in rows corresponding to the line of the lamellæ. In most grains the starch near the hilum is divided first into irregularly shaped granules which are very resistant. Gelatinization now begins with swelling of the hilum, and the finely granular portion, but not the coarse granules immediately surrounding the hilum, begins to gelatinize. Before gelatinization reaches the distal end, the granular starch here is invaded by several longitudinal fissures from the margin, which divide the material and apparently hasten gelatinization. The more resistant portion in the proximal end and sides, in the meantime, forms a thick, indistinctly striated and lamellated marginal band around the inner border, of which the rather coarse granules formed from the starch around the hilum are arranged at nearly regular intervals. This band becomes progressively thinner and more nearly transparent and finally is also gelatinized, the proximal margin last, and some time after the distal material is gelatinized, only the thin capsule and the resistant granules already mentioned are left. These granules persist for some time, growing smaller and more refractive and are finally gelatinized. Rarely the most resistant granules are found grouped together at the distal margin, and in such grains the proximal end and the marginal portion at the sides is gelatinized before the starch between the hilum and the distal end.

The gelatinized grains are large, thin-walled, not much distorted, except at the distal end, and retain some resemblance to the form of the untreated grain. In a moderate number of grains, dissolution of the capsule at various points and invasion of the grain by cracks at these points take place long before gelatinization is complete, and such grains become coarsely granular throughout, and are gelatinized and nearly completely dissolved so that only the curled-up capsule remains.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 38 per cent of the entire number of grains and 82 per cent of the total starch in 5 minutes; in about 44 per cent of the grains and 86 per cent of the total starch in 15 minutes; in about 55 per cent of the grains and 89 per cent of the total starch in 30 minutes; in about 58 per cent of the grains and 93 per cent of the total starch in 45 minutes; in about 65 per cent of the grains and 95 per cent of the total starch in 60 minutes. (Chart D 385.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 24 per cent of the grains and 52 per cent of the total starch in 5 minutes; in about 29 per cent of the grains and 68 per cent of the total starch in 15 minutes; in about 32 per cent of the grains and 78 per cent of the total starch in 30 minutes; in about 39 per cent of the grains and 86 per cent of the total starch in 45 minutes; in about 43 per cent of the grains and 89 per cent of the total starch in 60 minutes. (Chart D 386.)

The hilum is distinct and if 2 refractive fissures already exist in the untreated grain, they become wider and more extensive, and if not already present they quickly form. The lamellæ are at first moderately distinct, and become more distinct, then less distinct, and are finally obliterated. Gelatinization begins at the hilum which swells slightly, and in the portion of the grain included between the 2 fissures, already described, the hilum, and the distal margin becomes more refractive, and is divided into irregularly placed granules. In the majority of the grains, this granular mass is invaded at the distal margin by longitudinal fissures, and is the first part of the grain to be gelatinized. This is followed at once by the part immediately distal to the hilum, leaving the portion midway between the hilum and the distal margin ungelatinized, and this may remain so for a considerable time. The most resistant portion of the grain, however, is at the proximal end and sides nearby. As the hilum and the grain enlarge, this material forms a faintly lamellated, non-striated, marginal band which slowly becomes thinner and more nearly transparent until only the capsule is left. In a

moderate number of grains the proximal portion becomes gelatinized first and then the distal starch. In the two methods of gelatinization just described, the enlargement of the grain is greatest at the distal and the proximal ends, respectively. The gelatinized grains are large, have thin capsules, and are somewhat distorted, but retain some resemblance to the form of the untreated grain.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 38 per cent of the entire number of grains and 84 per cent of the total starch in 2 minutes; in about 56 per cent of the grains and 90 per cent of the total starch in 5 minutes; in about 76 per cent of the grains and 97 per cent of the total starch in 15 minutes. (Chart D 387.)

The reaction with *potassium sulphide* begins in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 6 per cent of the total starch in 30 minutes; in about 2 per cent of the grains and 7 per cent of the total starch in 45 minutes; in about the same of the grains and 8 per cent of the total starch in 60 minutes. (Chart D 388.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 39 per cent of the entire number of grains and 59 per cent of the total starch in 2 minutes; in about 60 per cent of the grains and 80 per cent of the total starch in 5 minutes; in about 70 per cent of the grains and 88 per cent of the total starch in 15 minutes; in about 83 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 88 per cent of the grains and 97 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 389.)

The hilum is very distinct and 2 refractive fissures, which are either already present in the untreated grain or soon form after the reagent is added, become larger and more extensive and branch out considerably as they near the distal margin. The lamellæ are moderately distinct and remain so, at the proximal end, throughout the greater part of the reaction. Gelatinization begins at the hilum which increases in size somewhat, as do also the 2 fissures already described, which by their many fine branches divide the grain at the distal end into fine granules. The portion of the grain between these fissures, the hilum, and the distal end, is invaded by many irregular, more or less longitudinal fissures, and as the hilum continues to enlarge and the grain to swell these fissures widen and divide this part of the starch into rather thin pyramids, from which spicules separate off, partially or completely, and are gelatinized. In many grains there are also wide cracks and longitudinal fissures which invade the distal portion of the grain from the margin, and when this occurs, the distal end and the material at the hilum both begin to gelatinize at nearly the same time. The more resistant part of the grain is at the proximal end and sides nearby, and this material forms a faintly lamellated, rather refractive band at the margin which later becomes coarsely striated, and so divided into granules. This band becomes progressively thinner and more nearly transparent as the grain enlarges, until finally only the thin capsule remains.

The gelatinized grains are swollen, and have rather thick capsules. They are not much distorted except at the distal ends, and retain some resemblance to the form of the untreated grain.

The reaction with *sodium sulphide* begins in a few grains immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 14 per cent of the total starch in 5 minutes; in about 10 per cent of the grains and 34 per cent of the total starch in 15 minutes; in about 22 per cent of the grains and 47 per cent of the total starch in 30 minutes; in about 32 per cent of the grains and 55 per cent of the total starch in 45 minutes; in about 37 per cent of the grains and 58 per cent of the total starch in 60 minutes. (Chart D 390.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 44 per cent of the entire number of grains and 55 per cent of the total starch in 5 minutes; in about 86 per cent of the grains and 89 per cent of the total starch in 10 minutes; in about 97 per cent of the grains and 99 per cent of the total starch in 15 minutes. (Chart D 391.)*

The hilum becomes distinct, attended by the formation of a very small bubble in most of the grains. The lamellæ are rather indistinct when the reagent is first added but become more distinct as the reaction advances. The grains become more refractive, the first part of the grain to show this increased refractivity is a narrow band about the margin. Gelatinization is preceded by a pitted appearance at the distal end of the grain, and begins at the corners of the distal margin. From these points it spreads along the distal margin, and then toward the proximal end. The starch becomes granular just preceding gelatinization, and this process may advance more rapidly on one side than on the other, or more rapidly in the central part than on the margins. In many grains 2 longitudinal fissures are seen to extend upward from the distal margin toward the hilum, and in such grains the portion between these fissures is gelatinized more rapidly than that nearer the margin. As the hilum is neared, in the progress of the reaction, the bubble, which is usually present, and which has been growing steadily larger, suddenly swells, then shrinks and disappears and the hilum enlarges rapidly, accompanying the rapid gelatinization of the marginal material on either side. The proximal portion is the last to be gelatinized and this may take place either rapidly or rather slowly, and is usually accompanied by considerable invagination of the capsule at this point. In a very few grains the proximal margin is gelatinized after the process of gelatinization has advanced about halfway from the distal end to the hilum. In such grains the most resistant part of the grain is just distal to the hilum. The gelatinized grains are much swollen, have rather thin capsules, and are very much distorted, retaining little if any resemblance to the form of the untreated grain.

*The reaction with this reagent begins at the margin of the grains of all species thus far studied. In the Iridaceæ the reaction is therefore more rapid in the grains in which the outline is more uneven or in which the most abrupt corners appear. The group of *I. persica* var. *purpurea*, *I. sindjarensis*, and *I. pursind* is the most resistant to this reagent, while it is the least resistant to most of the reagents. The outline of the grains of this group is more curved and possesses fewer inequalities than those of the other species of this genus studied.

The reaction with *calcium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 13 per cent of the total starch in 5 minutes; in about 9 per cent of the grains and 30 per cent of the total starch in 15 minutes; in about 21 per cent of the grains and 45 per cent of the total starch in 30 minutes; in about 24 per cent of the grains and 54 per cent of the total starch in 45 minutes; in about 27 per cent of the grains and 60 per cent of the total starch in 60 minutes. (Chart D 392.)

The reaction with *uranium nitrate* begins in a few grains in 30 seconds. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 20 per cent of the total starch in 15 minutes; in about 6 per cent of the grains and 22 per cent of the total starch in 30 minutes; in about 11 per cent of the grains and 25 per cent of the total starch in 45 minutes; in about 15 per cent of the grains and 29 per cent of the total starch in 60 minutes. (Chart D 393.)

The reaction with *strontium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 12 per cent of the total starch in 5 minutes; in about 21 per cent of the grains and 48 per cent of the total starch in 15 minutes; in about 44 per cent of the grains and 67 per cent of the total starch in 30 minutes; in about 52 per cent of the grains and 78 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 80 per cent of the total starch in 60 minutes. (Chart D 394.)

The reaction with *cobalt nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 0.5 per cent of the grains and 4 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 6 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 7 per cent of the total starch in 45 minutes; in about 2 per cent of the grains and 8 per cent of the total starch in 60 minutes. (Chart D 395.)

The reaction with *copper nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 12 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 19 per cent of the total starch in 15 minutes; in about 14 per cent of the grains and 50 per cent of the total starch in 30 minutes; in about 19 per cent of the grains and 54 per cent of the total starch in 45 minutes; in about 29 per cent of the grains and 61 per cent of the total starch in 60 minutes. (Chart D 396.)

The reaction with *cupric chloride* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 16 per cent of the grains and 42 per cent of the total starch in 15 minutes; in about 26 per cent of the grains and 61 per cent of the total starch in 30 minutes; in about 29 per cent of the grains and 64 per cent of the total starch in 45 minutes; in about 31 per cent of the grains and 70 per cent of the total starch in 60 minutes. (Chart D 397.)

The reaction with *barium chloride* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 9 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 10 per cent of the total starch in 45 minutes; in about 3 per cent of the grains and 11 per cent of the total starch in 60 minutes. (Chart D 398.)

The reaction with *mercuric chloride* begins in a few grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 11 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 15 per cent of the total starch in 30 minutes; in about 7 per cent of the grains and 22 per cent of the total starch in 45 minutes; in about 7 per cent of the grains and 25 per cent of the total starch in 60 minutes. (Chart D 399.)

Iris trojana (Pollen Parent).

(Plate 18, fig. 104, Charts D 379 to D 399.)

Histologic Properties.

In *form* the grains, as in *I. iberica,* are usually simple and isolated, and there are even fewer aggregates of 2, 3, or more components than in *I. iberica.* There are, however, many more compound grains than in this species and these are of several types. The first type consists of 2 grains, each consisting of a hilum and 4 or 5 lamellæ adherent and held together, except for 1 or 2 outer lamellæ, which encircle the margin only on 1 side, by 9 to 10 secondary lamellæ, and so constitute a double proximal end to a large, elongated grain. The grains of the second type are simply irregular masses of homogeneous-appearing grains, whose hila alone show that separate grains are present, the whole bound together by one thick layer of starch. The third type consists of 2 grains, each consisting of a hilum and 3 or 4 lamellæ held together by 1 or 2 common secondary lamellæ. The grains are more irregular in form than *I. iberica* and the irregularities are due to the following causes in the order of the frequency of their occurrence: (1) Deep triangular or cone-shaped notches in the distal margin, these occurring in nearly every grain; (2) a secondary set of lamellæ, whose longitudinal axis is at an angle (usually a right angle) with that of the primary grain; (3) deviation of the axis of a grain with consequent bending of the grain, usually in the middle, but sometimes at the distal end; (4) shallow depressions and elevations of the surface, producing a somewhat wavy or undulating outline; (5) an occasional small pointed, or large rounded and irregular, protuberance from either end or from the sides. The conspicuous forms are elongated elliptical, in which the flattening of the distal end is more common than in *I. iberica,* and boot-shaped. The additional forms are shortened and regular T shape, pyriform, napiform, club-shaped, ovoid with flattened distal end, round and nearly round, and triangular. The grains as in *I. iberica* are not flattened.

The *hilum* is more distinct than in *I. iberica* and is much more frequently fissured than in those grains and the fissures take the following forms: (1) Large flying-bird; (2) straight, transverse line, sometimes branched; (3) 2 fissures forming an angle. Not infrequently when the hilum is fissured by a straight transverse fissure, 2 refractive fissures, as in *I. iberica*, are seen in the interior of the grain extending from the hilum distally. The hilum is eccentric from 0.24 to 0.1, usually 0.18, of the longitudinal axis, and is less eccentric than that of *I. iberica.*

The *lamellæ* are coarser and more distinct than in *I. iberica.* Near the hilum they are circular in form and continuous, and in the rest of the grain they appear to be discontinuous and to follow the form of the outline of the grain. They are more apt to be irregular than in *I. iberica,* and the irregularity is most conspicuous midway between the hilum and margin, and follows and emphasizes the form of the notch in the distal margin. The lamellæ near the distal end are usually coarser than those near the hilum, and there is frequently a very refractive, coarse, continuous lamella midway between the hilum and margin, and less often 2 or 3 such lamellæ dividing the rest of the lamellæ into groups of varying size. The number of lamellæ counted on the larger grains varies from 14 to 22, usually 16, and more than in *I. trojana.*

In *size* the grains vary from the smaller which are 5 by 5μ, to the larger which are 48 by 22μ, in length and breadth. The common sizes are 28 by 20μ and 30 by 14μ. The common sizes are 8μ longer and 6μ broader, and 10μ longer and no narrower, than the common sizes of *I. iberica.*

Polariscopic Properties.

The *figure* is distinct and somewhat less well defined than in *I. iberica.* The lines cross at a more acute angle which varies much less in size in different grains than in *I. iberica.* They are more often bent than in *I. iberica* but rarely bisected as in that starch.

The *degree of polarization* varies from low to moderately high (value 45), 5 units less than in *I. iberica.* There is usually some variation in a given aspect of a grain. It is usually lower in the area between the two arms of the cross than elsewhere.

With *selenite* the quadrants are not quite so well defined as in either parent. They are usually somewhat more unequal in size and irregular in shape than in *I. iberica.* The colors are usually somewhat less pure than in *I. iberica.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate violet tinged with blue (value 50), 10 units more than in *I. iberica.* The color has more of a bluish tint than in *I. iberica,* and deepens more rapidly until it is very deep and has assumed still more of a bluish tint. With 0.125 per cent Lugol's solution the grains all color a light to moderate violet tinged with blue, more than in *I. iberica.* The color as in *I. iberica* deepens rapidly until it is deep and has assumed more of a bluish tint. After heating in water until all the grains are completely gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* all color a moderately deep or deep indigo, less than in *I. iberica,* and the *solution* a deep indigo, more than in *I. iberica.* If the preparation is boiled for 2 minutes and then treated with an excess of iodine, more *grain-residues* than in *I. iberica* are colored a light indigo; the *capsules,* a wine-red or a violet, which is not so deep as in *I. iberica;* and the *solution* colors a very deep indigo, as in *I. iberica.*

Aniline Reactions.

With *gentian violet* the grains, as in *I. iberica,* stain very lightly at once, and in 30 minutes they are moderately stained (value 50), 10 units more than in *I. iberica.* There are a few grains which are deeply, the rest are moderately, or light to moderately, stained.

With *safranin* the grains, as in *I. iberica,* stain very lightly at once, and in 30 minutes they are moderately stained (value 50), 5 units more than in *I. iberica.* The staining is the same as with gentian violet.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 70° to 71.5° C., and of all 73.2° to 75° C., mean 74.1° C. This is 2.3° C. higher than that of *I. iberica.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 1 minute. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 18 per cent of the total starch in 5 minutes; in about 35 per cent of the grains and 51 per cent of the total starch in 15 minutes; in about 62 per cent of the grains and 77 per cent of the total starch in 30 minutes; in about 77 per cent of the grains and 88 per cent of the total starch in 45 minutes; in about 84 per cent of the grains and 93 per cent of the total starch in 60 minutes. (Chart D 379.)

The hilum becomes distinct as in *I. iberica,* attended by the formation of a bubble in fewer grains than in that starch. The lamellæ are at first more distinct but become obliterated during the course of the reaction as in *I. iberica.* The grain becomes more refractive, the first part to show this change is a rather narrow band at the margin which is narrower' and more refractive than a similar band in *I. iberica.* Gelatinization begins in the same manner as in *I. iberica* at the corners of the distal margin and the progress of gelatinization is similar to that described under *I. iberica,* except that the 2 internal fissures which extend longitudinally on either side are more prominent in these grains and extend around the hilum, thus completely separating the marginal from the central part of the grain, and either may be gelatinized first. In more grains than in *I. iberica,* where gelatinization has progressed about halfway from the distal end to the hilum, the proximal starch may be gelatinized and the two processes approach one another, the most resistant portion being just distal to the hilum.

The gelatinized grains are as much swollen, have as thin capsules, and are as distorted as in *I. iberica.*

The reaction with *chromic acid* begins in 30 seconds. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 29 per cent of the total starch in 5 minutes; in about 37 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 75 per cent of the grains and 98 per cent of the total starch in 30 minutes; in about 95 per cent of the grains and in more than 99 per cent of the total starch

in 45 minutes; in more than 99 per cent of the grains and total starch in 60 minutes. (Chart D 380.)

The reaction with *pyrogallic acid* begins in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 28 per cent of the total starch in 5 minutes; in about 17 per cent of the grains and 77 per cent of the total starch in 15 minutes; in about 43 per cent of the grains and 84 per cent of the total starch in 30 minutes; in about 52 per cent of the grains and 93 per cent of the total starch in 45 minutes; in about 64 per cent of the grains and 96 per cent of the total starch in 60 minutes. (Chart D 381.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 18 per cent of the entire number of grains and 70 per cent of the total starch in 5 minutes; in about 41 per cent of the grains and 82 per cent of the total starch in 15 minutes; in about 50 per cent of the grains and 86 per cent of the total starch in 30 minutes; in about 59 per cent of the grains and 90 per cent of the total starch in 45 minutes; in about 70 per cent of the grains and 93 per cent of the total starch in 60 minutes. (Chart D 382.)

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 80 per cent of the entire number of grains and 98 per cent of the total starch in 2 minutes; in about 97 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 383.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 30 per cent of the entire number of grains and 72 per cent of the total starch in 5 minutes; in about 50 per cent of the grains and 83 per cent of the total starch in 15 minutes; in about 78 per cent of the grains and 88 per cent of the total starch in 30 minutes; little if any further advance in 45 minutes, and about 90 per cent in 60 minutes. (Chart D 384.)

The hilum and lamellæ both become more distinct than in *I. iberica*. Gelatinization begins at the hilum and is as in *I. iberica* preceded by the enlargement and extension of 2 refractive fissures which are usually already present in the untreated grain; these fissures are much more prominent, larger, and more branching than in *I. iberica*. The material included between these fissures, the hilum and the distal margin, become more refractive in appearance than in *I. iberica* and is divided into coarse granules. Now the hilum enlarges, and in a small majority of the grains the proximal starch is the least resistant so that the hilum enlarges more rapidly in that direction than toward the distal end. The portion here and at the sides forms a finely striated and distinctly lamellated marginal band which becomes rapidly thinner and more nearly transparent. The distal material is then gelatinized except a group of coarse, refractive lamellæ at the distal margin which remain long after the rest of the grain is gelatinized. In the rest of the grains the proximal marginal band is gelatinized after the distal region, but in no grains are there seen the coarse granules arranged around the inner border of this band such as were seen in *I. iberica.*

The gelatinized grains are large and capsules have thicker walls and are somewhat less distorted than in *I. iberica*. There are fewer grains partially or completely dissolved than in *I. iberica.*

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 44 per cent of the entire number of grains and 84 per cent of the total starch in 5 minutes; in about 68 per cent of the grains and 92 per cent of the total starch in 15 minutes; in about 72 per cent of the grains and 96 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes, respectively. (Chart D 385.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 24 per cent of the entire number of grains and 58 per cent of the total starch in 5 minutes; in about 58 per cent of the grains and 83 per cent of the total starch in 15 minutes; in about 75 per cent of the grains and 92 per cent of the total starch in 30 minutes; in about 84 per cent of the grains and 93 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 94 per cent of the total starch in 60 minutes. (Chart D 386.)

The hilum is more distinct than in *I. iberica,* and if 2 refractive fissures are already present in the untreated grain, they grow wider and more extensive, and if they are not present, they form soon after the reagent is added. The lamellæ are more distinct than in *I. iberica,* and remain visible longer. Gelatinization, as in *I. iberica,* begins at the hilum, which enlarges somewhat, and the 2 fissures already described extend further toward the distal margin, but in many grains they turn toward one another before they reach the margin and unite so as to completely separate the inner central part of the grain from the marginal portion. In such grains the marginal starch becomes more and more refractive and is gelatinized most rapidly at the proximal end, while the inner portion is divided irregularly into numerous granules by irregular fissures, and may remain ungelatinized for some time. In other grains, the process begins at the hilum and extends down to the distal end, and the most resistant starch is at the proximal end in some grains, but at the distal end in others, this latter much more frequently than in *I. iberica,* and in no case was gelatinization observed to start, as in many grains of *I. iberica,* at the distal margin first.

The gelatinized grains are much swollen with thicker capsules, and are not so distorted and retain more resemblance to the form of the untreated grain than in *I. iberica.*

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 48 per cent of the entire number of grains and 88 per cent of the total starch in 2 minutes; in about 72 per cent of the grains and 95 per cent of the total starch in 5 minutes; in about 80 per cent of the grains and 98 per cent of the total starch in 15 minutes. (Chart D 387.)

The reaction with *potassium sulphide* begins in 30 seconds. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 11 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 16 per cent of the total starch in 30 minutes; in about 5 per cent of the grains and 20 per cent of the total starch in 45 minutes;

in about 6 per cent of the grains and 23 per cent of the total starch in 60 minutes. (Chart D 388.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 36 per cent of the entire number of grains and 75 per cent of the total starch in 2 minutes; in about 63 per cent of the grains and 87 per cent of the total starch in 5 minutes; in about 75 per cent of the grains and 91 per cent of the total starch in 15 minutes; in about 82 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 88 per cent of the grains and 97 per cent of the total starch in 45 minutes; little if any advance in 60 minutes. (Chart D 389.)

The hilum is more distinct than in *I. iberica,* and the 2 refractive fissures which are usually present in the untreated grain, become wider, more prominent, and more branched, than in *I. iberica.* The lamellæ are more distinct than in *I. iberica* and remain visible for a longer time. Gelatinization begins at the hilum as in *I. iberica,* and the refractive fissures already described become much wider and much more branched toward the distal end, and a third very distinct, straight, longitudinal fissure extends down the center of the grain from the hilum to the distal margin. As gelatinization proceeds and the hilum enlarges, this central fissure disappears and the portion of the grain included between the 2 refractive, marginal fissures, the hilum and the distal margin is broken up into refractive granules which are arranged in rows corresponding to the lamellar arrangement. Gelatinization usually begins at the hilum and proceeds toward the distal end, without the division of the grain into pyramidal portions by fissures as in *I. iberica,* and the distal starch rarely begins to be gelatinized at the same time that the hilum begins as in *I. iberica.* The most resistant part of the grain is in most of the grains at the proximal end and sides nearby as in *I. iberica,* and this portion, as the hilum and the grain swell, forms a lamellated, striated band at the margin, which becomes progressively thinner and more nearly transparent until only the thin capsule is left. In a moderately large minority, however, this part of the grain seems the least resistant, and is gelatinized before all of the distal material. The gelatinized grains are swollen, and have somewhat thicker capsules and are more distorted than in *I. iberica.*

The reaction with *sodium sulphide* begins in a few grains immediately. Complete gelatinization occurs in about 10 per cent of the entire number of grains and 39 per cent of the total starch in 5 minutes; in about 19 per cent of the grains and 58 per cent of the total starch in 15 minutes; in about 39 per cent of the grains and 67 per cent of the total starch in 30 minutes; in about 39 per cent of the grains and 72 per cent of the total starch in 45 minutes; in about 48 per cent of the grains and 77 per cent of the total starch in 60 minutes. (Chart D 390.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 70 per cent of the entire number of grains and 77 per cent of the total starch in 5 minutes; in more than 99 per cent of the grains and total starch in 10 minutes. (Chart D 391.)

The hilum is as distinct as in *I. iberica,* but a bubble is not nearly so frequently formed there as in that starch. The lamellæ are at first indistinct, but later become more distinct than in *I. iberica.* The grains, as in *I. iberica,* become more refractive in appearance after the addition of the reagent, and the first indication of this change is the appearance of a moderately narrow, refractive band about the margin, which is not so narrow and is more refractive than in *I. iberica.* Gelatinization is not always preceded by a pitted appearance of the distal end of the grain, but begins at the corners of the distal margin as in *I. iberica.* The progress of gelatinization is very similar to that already described under *I. iberica,* except that the grain is not so apt to become granular in appearance just preceding gelatinization, and the process is much smoother. In many less grains than in *I. iberica* are 2 longitudinal fissures observed, extending from the distal margin toward the hilum, and there are many more grains than in *I. iberica* in which the proximal end is gelatinized when gelatinization has progressed halfway from the distal margin to the hilum.

The gelatinized grains are much swollen, have thicker capsules, and are somewhat less distorted than in *I. iberica.*

The reaction with *calcium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in about 25 per cent of the grains and 66 per cent of the total starch in 15 minutes; in about 34 per cent of the grains and 71 per cent of the total starch in 30 minutes; in about 39 per cent of the grains and 75 per cent of the total starch in 45 minutes; in about 50 per cent of the grains and 79 per cent of the total starch in 60 minutes. (Chart D 392.)

The reaction with *uranium nitrate* begins in a few grains in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 25 per cent of the total starch in 15 minutes; in about 10 per cent of the grains and 32 per cent of the total starch in 30 minutes; in about 14 per cent of the grains and 40 per cent of the total starch in 45 minutes; in about 16 per cent of the grains and 45 per cent of the total starch in 60 minutes. (Chart D 393.)

The reaction with *strontium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 21 per cent of the total starch in 5 minutes; in about 28 per cent of the grains and 69 per cent of the total starch in 15 minutes; in about 47 per cent of the grains and 80 per cent of the total starch in 30 minutes; in about 68 per cent of the grains and 86 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 88 per cent of the total starch in 60 minutes. (Chart D 394.)

The reaction with *cobalt nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 15 minutes; in about the same percentage of the grains and 8 per cent of the total starch in 30 minutes; in about 1 per cent of the grains and 9

per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 395.)

The reaction with *copper nitrate* begins in a few grains in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 16 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 25 per cent of the total starch in 15 minutes; in about 17 per cent of the grains and 70 per cent of the total starch in 30 minutes; in about 25 per cent of the grains and 76 per cent of the total starch in 45 minutes; in about 34 per cent of the grains and 81 per cent of the total starch in 60 minutes. (Chart D 396.)

The reaction with *cupric chloride* begins in a few grains immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 15 per cent of the total starch in 5 minutes; in about 10 per cent of the grains and 50 per cent of the total starch in 15 minutes; in about 27 per cent of the grains and 70 per cent of the total starch in 30 minutes; in about 34 per cent of the grains and 77 per cent of the total starch in 45 minutes; in about 39 per cent of the grains and 81 per cent of the total starch in 60 minutes. (Chart D 397.)

The reaction with *barium chloride* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 6 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 7 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 9 per cent of the total starch in 45 minutes; in about 3 per cent of the grains and 11 per cent of the total starch in 60 minutes. (Chart D 398.)

The reaction with *mercuric chloride* begins in a few grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 18 per cent of the total starch in 15 minutes; in about 10 per cent of the grains and 32 per cent of the total starch in 30 minutes; in about 20 per cent of the grains and 40 per cent of the total starch in 45 minutes; in about 20 per cent of the grains and 46 per cent of the total starch in 60 minutes. (Chart D 399.)

Iris ismali (Hybrid).

(Plate 18, fig. 105; Charts D 379 to D 399.)

Histologic Properties.

In *form* the grains are usually simple and isolated, and there are not so many aggregates of 2 or 3 components as in either parent, but many more compound grains than in *I. iberica* and a few more than in *I. trojana.* The compound grains are of the two types already described under *I. iberica.* The grains are much more irregular than in *I. iberica* and somewhat more than in *I. trojana,* and the irregularities are due to the following causes, in their order of frequency of occurrence: (1) Depressions and elevations in the surface giving an undulating or wavy outline to the grain; (2) a secondary set of lamellæ whose longitudinal axis is at an angle, usually a right angle, with that of the primary set; (3) deviation of the axis of the grain with a consequent bending, usually at the middle; (4) rounded protuberances from the sides or either end; (5) rarely, a shallow notch in the distal margin. The conspicuous forms are round and nearly round, elongated elliptical with flattened distal end, and irregular rather broad ovoid with rounded distal end. The additional forms are pyriform, boot-shaped, napiform, triangular, and irregularly quadrilateral with rounded angles. The grains, as in the parents, are not flattened. In *form I. ismali* shows a closer relationship to *I. iberica* than to *I. trojana.*

The *hilum* is as distinct as in *I. iberica* and is even less frequently fissured than in that starch, and when fissures occur they are of the same character as noted in *I. iberica.* The hilum is eccentric from 0.33 to 0.16, usually 0.23, of the longitudinal axis. In the character of the hilum *I. ismali* shows a closer relationship to *I. iberica,* but in the degree of eccentricity to *I. trojana;* the latter being 0.08 less eccentric than in *I. iberica* and 0.05 less eccentric than in *I. trojana.*

The *lamellæ* are less distinct and are not so coarse as in *I. iberica,* and can not be demonstrated on all the grains. They have the same arrangement as in *I. iberica,* but are not so apt to be irregular. The number counted on some of the larger grains varies from 6 to 10, usually 8, less than in either parent.

In character, arrangement, and number of the lamellæ, *I. ismali* shows a closer relationship to *I. iberica* than to *I. trojana.*

In *size* the grains vary from the smaller which are 2 by 2μ, to the larger which are 22 by 10μ, in length and breadth. The common sizes are 14 by 10μ and 14 by 12μ. In size *I. ismali* is much smaller than either parent, the common sizes being 6μ shorter by 4μ narrower, or 6μ shorter by 2μ narrower, than in *I. iberica,* and 14μ shorter by 8μ narrower, and 16μ shorter by 4μ narrower, than in *I. trojana.* It is therefore closer to *I. iberica* in size than to *I. trojana.*

Polariscopic Properties.

The *figure* is somewhat less distinct and less well defined than in either parent, in this showing a closer relationship to *I. trojana* than to *I. iberica.* The lines as in *I. trojana* cross at a very acute angle which does not vary greatly in size in the different grains. They are somewhat less irregular than in *I. trojana* and somewhat more than in *I. iberica.*

The *degree of polarization* varies from low to moderately high (value 40), 10 units lower than in *I. trojana* and 5 units lower than in *I. iberica.* There is less variation in a given aspect of an individual grain than in either parent. In this respect the hybrid is closer to *I. iberica* than *I. trojana.*

With *selenite* the quadrants are less clear-cut than in either parent, in this respect more closely resembling *I. trojana.* They are as unequal in size and less irregular in form than in *I. trojana* and more irregular than in *I. iberica.* The colors are less pure than in either parent, in this respect more closely resembling *I. trojana* than *I. iberica.*

In the character of the figure and the appearance with selenite *I. ismali* shows a closer relationship to *I. trojana,* and in the degree of polarization to *I. iberica.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color light to moderate violet tinged with blue (value 40), the same as in *I. iberica* and 10 units less than in *I. trojana*. With 0.125 per cent Lugol's solution the grains all color a light violet the same as in *I. iberica* and less than in *I. trojana*. After heating in water until all the grains are completely gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* color a deep or a moderately deep indigo as in *I. iberica* and more than in *I. trojana;* and the *solution* a deep indigo as in *I. iberica* and less than in *I. trojana*. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution as few of the *grain-residues* as in *I. iberica* are colored a very light indigo; the *capsules* a deep wine-red as in *I. iberica;* and the *solution* a very deep indigo as in both parents. Qualitatively and quantitatively the reaction with iodine shows a closer relationship to *I. iberica* than to *I. trojana*.

Aniline Reactions.

With *gentian violet* the grains, as in the parents, stain very lightly at once, and in 30 minutes they are light to moderately stained (value 40) the same as in *I. iberica* and 10 units less than in *I. trojana*.

With *safranin* the grains, as in the parents, stain very lightly at once, and in 30 minutes they are moderately stained (value 45), the same as in *I. iberica* and 5 units less than in *I. trojana*.

In the reactions with aniline stains *I. ismali* shows a closer relationship to *I. iberica* than to *I. trojana*.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 69° to 71° C., and of all is 72° to 74° C., mean 73° C. The temperature of gelatinization of *I. ismali* is 1.2° C. more than that of *I. iberica* and 1.1° C. less than that of *I. trojana*. It is, therefore, midway between the temperatures of gelatinization of the two parents.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 1 minute. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 29 per cent of the grains and 42 per cent of the total starch in 15 minutes; in about 66 per cent of the grains and 76 per cent of the total starch in 30 minutes; in about 78 per cent of the grains and 86 per cent of the total starch in 45 minutes; in about 83 per cent of the grains and 90 per cent of the total starch in 60 minutes. (Chart D 379.)

The hilum as in the parents is distinct, and a bubble is formed there nearly as often as in *I. iberica*. The lamellæ are not so distinct as in either parent, and can not be demonstrated in some grains. The grains as in the parents become more refractive, and this is first seen in the formation of a broad not very refractive band about the margin, as in *I. iberica*. Gelatinization begins, as in the parents, at the corners of the distal margin, and the progress is the same as already described under *I. iberica,* except that there are more grains in which gelatinization begins at the proximal end when the process is halfway between the distal end and the hilum, as in *I. trojana*. The gelatinized grains are large and are as distorted as in the parents. In this reaction *I. ismali* shows qualitatively a closer relationship to *I. iberica* than to *I. trojana*.

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 9 per cent of the total starch in 5 minutes; in about 9 per cent of the grains and 80 per cent of the total starch in 15 minutes; in about 34 per cent of the grains and 92 per cent of the total starch in 30 minutes; in about 67 per cent of the grains and 98 per cent of the total starch in 45 minutes; in about 92 per cent of the grains and in more than 99 per cent of the total starch in 60 minutes. (Chart D 380.)

The reaction with *pyrogallic acid* begins in 30 seconds. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 16 per cent of the total starch in 5 minutes; in about 33 per cent of the grains and 75 per cent of the total starch in 15 minutes; in about 48 per cent of the grains and 81 per cent of the total starch in 30 minutes; in about 56 per cent of the grains and 92 per cent of the total starch in 45 minutes; in about 68 per cent of the grains and 96 per cent of the total starch in 60 minutes. (Chart D 381.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 7 per cent of the entire number of grains and 58 per cent of the total starch in 5 minutes; in about 24 per cent of the grains and 75 per cent of the total starch in 15 minutes; in about 41 per cent of the grains and 82 per cent of the total starch in 30 minutes; in about 41 per cent of the grains and 89 per cent of the total starch in 45 minutes; in about 51 per cent of the grains and 92 per cent of the total starch in 60 minutes. (Chart D 382.)

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 77 per cent of the entire number of grains and 91 per cent of the total starch in 2 minutes; in about 91 per cent of the grains and 97 per cent of the total starch in 5 minutes. (Chart D 383.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 15 per cent of the entire number of grains and 64 per cent of the total starch in 5 minutes; in about 43 per cent of the grains and 82 per cent of the total starch in 15 minutes; in about 59 per cent of the grains and 87 per cent of the total starch in 30 minutes; very little if any further advance in 45 and 60 minutes, respectively. (Chart D 384.)

The hilum is as distinct as in *I. iberica,* but the lamellæ are not so distinct as in those grains and not nearly so distinct as in *I. trojana*. Gelatinization is preceded as in both parents by an extension and enlargement of 2 refractive fissures, which are usually already present in the untreated grain, and the increased refractivity and the granulation of the starch included between the 2 fissures, the hilum, and the distal margin; but the fissures are not so distinct nor so extensive as in either parent, and the material included between them does not become so refractive, nor so coarsely granular as in *I. trojana,* but the same as in *I. iberica*. The progress of gelatinization is the same in most grains as in *I. iberica,*

except the proximal end is the least resistant part in considerably more grains than in *I. iberica,* but in less than in *I. trojana.*

The gelatinized grains are large and have somewhat thicker capsules than in *I. iberica,* but are as much distorted and retain as much of the form of the untreated grain as do those grains. There are somewhat fewer grains partially or completely dissolved than in *I. iberica,* more than in *I. trojana.*

In this reaction *I. ismali* shows qualitatively a closer relationship to *I. iberica* than to *I. trojana.*

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 26 per cent of the entire number of grains and 77 per cent of the total starch in 5 minutes; in about 37 per cent of the grains and 81 per cent of the total starch in 15 minutes; in about 48 per cent of the grains and 84 per cent of the total starch in 30 minutes; in about 51 per cent of the grains and 88 per cent of the total starch in 45 minutes; in about 62 per cent of the grains and 93 per cent of the total starch in 60 minutes. (Chart D 385.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 26 per cent of the entire number of grains and 65 per cent of the total starch in 5 minutes; in about 43 per cent of the grains and 85 per cent of the total starch in 15 minutes; in about 51 per cent of the grains and 89 per cent of the total starch in 30 minutes; in about 57 per cent of the grains and 91 per cent of the total starch in 45 minutes; in about 65 per cent of the grains and 93 per cent of the total starch in 60 minutes. (Chart D 386.)

The hilum is as distinct as in *I. iberica,* and the same phenomenon of 2 refractive fissures is noted as in those grains. The lamellæ are not so distinct as in either parent. Gelatinization as in the parents begins at the hilum, and the 2 fissures are more delicate and branch more widely than in *I. iberica.* Gelatinization progresses as in *I. iberica,* except that there is more granulation, the granules are larger and more refractive, and gelatinization more often begins at the distal margin than in *I. iberica;* in fact, in some grains gelatinization may occur at the corners of the distal margin before there are any definite signs of the reaction beginning in any other part of the grain.

The gelatinized grains are much swollen and the capsules are of the same thickness and the grains are as much distorted as in *I. iberica.*

In this reaction *I. ismali* shows qualitatively, a closer relationship to *I. iberica* than to *I. trojana.* Some points noted as characteristic of the reaction in *I. iberica* are accentuated in the hybrid.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 34 per cent of the entire number of grains and 82 per cent of the total starch in 2 minutes; in about 65 per cent of the grains and 93 per cent of the total starch in 5 minutes; in about 78 per cent of the grains and 97 per cent of the total starch in 15 minutes. (Chart D 387.)

The reaction with *potassium sulphide* begins in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 10 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 13 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes, respectively. (Chart D 388.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 36 per cent of the entire number of grains and 60 per cent of the total starch in 2 minutes; in about 60 per cent of the grains and 82 per cent of the total starch in 5 minutes; in about 70 per cent of the grains and 94 per cent of the total starch in 15 minutes; in about 88 per cent of the grains and 96 per cent of the total starch in 30 minutes; in about 90 per cent of the grains and 98 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 389.)

The hilum is as distinct as in *I. iberica,* and the lamellæ are less distinct than in either parent, but nearer to *I. iberica* than to *I. trojana.* Gelatinization, as in the parents, begins at the hilum which enlarges, and the 2 refractive fissures usually already present in the untreated grain are not so prominent nor so branched as in *I. iberica* and much less than in *I. trojana.* The progress of gelatinization is similar to that in *I. iberica,* except that fewer grains are invaded by fissures at the distal end and start to gelatinize there as in *I. iberica,* and the grains as a whole are divided much more irregularly by fissures, becoming often truly granular as in *I. trojana.* The gelatinized grains are swollen and have as thick capsules, but are somewhat less distorted than in *I. iberica.* In this reaction *I. ismali* shows qualitatively a closer relationship to *I. iberica* than to *I. trojana.*

The reaction with *sodium sulphide* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 17 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 35 per cent of the total starch in 15 minutes; in about 20 per cent of the grains and 53 per cent of the total starch in 30 minutes; in about 33 per cent of the grains and 69 per cent of the total starch in 45 minutes; in about 44 per cent of the grains and 75 per cent of the total starch in 60 minutes. (Chart D 390.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 65 per cent of the entire number of grains and 75 per cent of the total starch in 5 minutes; in more than 99 per cent of the grains and total starch in 10 minutes. (Chart D 391.)

The hilum is as distinct as in *I. iberica,* and a bubble is more frequently found there than in *I. iberica,* but is smaller than in that starch. The lamellæ are less distinct throughout the reaction than in *I. iberica.* The grains become more refractive in appearance after the addition of the reagent, and the marginal band which is first formed is more refractive than in *I. iberica* and the same as in *I. trojana.* Gelatinization is preceded by a pitted appearance at the distal end, and begins at the corners of the distal margin as in *I. iberica.* The progress of gelatinization is the same as that already described under *I. iberica,* except that it is more irregular and is attended by more granulation than in that starch. There are also more grains in which the proximal end is gelatinized after gelatinization has preceded halfway from the distal margin to the hilum, in this respect more like *I. trojana.* The gelatinized grains are much

swollen and have somewhat thicker capsules than in *I. iberica,* but not so thick as in *I. trojana.* They are nearly as much distorted as in *I. iberica.* In this reaction *I. ismali* shows qualitatively a closer relationship to *I. iberica* than to *I. trojana.*

The reaction with *calcium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 19 per cent of the total starch in 5 minutes; in about 14 per cent of the grains and 32 per cent of the total starch in 15 minutes; in about 24 per cent of the grains and 48 per cent of the total starch in 30 minutes; in about 26 per cent of the grains and 54 per cent of the total starch in 45 minutes; in about 38 per cent of the grains and 62 per cent of the total starch in 60 minutes. (Chart D 392.)

The reaction with *uranium nitrate* begins in a few grains in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 14 per cent of the total starch in 15 minutes; in about 7 per cent of the grains and 22 per cent of the total starch in 30 minutes; in about 11 per cent of the grains and 29 per cent of the total starch in 45 minutes; in about 15 per cent of the grains and 33 per cent of the total starch in 60 minutes. (Chart D 393.)

The reaction with *strontium nitrate* begins in a few grains immediately. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 13 per cent of the grains and 50 per cent of the total starch in 15 minutes; in about 32 per cent of the grains and 68 per cent of the total starch in 30 minutes; in about 41 per cent of the grains and 80 per cent of the total starch in 45 minutes; in about 50 per cent of the grains and 86 per cent of the total starch in 60 minutes. (Chart D 394.)

The reaction with *cobalt nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; very slight advance in 30 and 45 minutes; in less than 0.5 per cent of the grains and 3 per cent of the total starch in 60 minutes. (Chart D 395.)

The reaction with *copper nitrate* begins in a few grains in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 22 per cent of the total starch in 15 minutes; in about 16 per cent of the grains and 54 per cent of the total starch in 30 minutes; in about 18 per cent of the grains and 60 per cent of the total starch in 45 minutes; in about 23 per cent of the grains and 63 per cent of the total starch in 60 minutes. (Chart D 396.)

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 22 per cent of the total starch in 15 minutes; in about 12 per cent of the grains and 51 per cent of the total starch in 30 minutes; in about 25 per cent of the grains and 61 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 68 per cent of the total starch in 60 minutes. (Chart D 397.)

The reaction with *barium chloride* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about 0.5 per cent of the grains and 2 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 3 per cent of the total starch in 45 minutes; in about 1 per cent of the grains and 5 per cent of the total starch in 60 minutes. (Chart D 398.)

The reaction with *mercuric chloride* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 1 per cent of the grains and 3 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 8 per cent of the total starch in 30 minutes; in about 2 per cent of the grains and 9 per cent of the total starch in 45 minutes; in about 4 per cent of the grains and 12 per cent of the total starch in 60 minutes. (Chart D 399.)

31. Starches of Iris iberica, I. cengialti, and I. dorak.

Starch of *Iris iberica* (seed parent) is described in pages 636 to 640.

Iris cengialti (Pollen Parent).

(Plates 18 and 19, figs. 107 and 109; Charts D 400 to D 420.)

Histologic Properties.

In *form* the grains are usually simple and isolated, but both compound grains and aggregates are occasionally seen. The compound grains belong to but 1 type: 3 to 5 or 6 small component grains, each consisting of a hilum and 2 or 3 lamellæ, are massed irregularly and surrounded by one common layer of starch. The aggregates are generally doublets of equal-sized grains. The grains are usually moderately regular, and any irregularities which may occur are due to the following causes: (1) Shallow depressions and elevations of the distal surface and margin, producing a wavy or undulating outline; (2) a secondary set of lamellæ whose longitudinal axis is at a right angle with that of the primary set; (3) deviation of the longitudinal axis and consequent bending of the grain; (4) large or small, rounded projections from the sides or ends; (5) rarely, a narrow notch in the middle of the distal margin. The conspicuous forms are ovoid, and elliptical with flattened distal end. The additional forms are nearly round, triangular with rounded angles, boot-shaped, and club-shaped. The grains are not flattened.

The *hilum* when not fissured is a moderately distinct, small, round spot. It is usually fissured, and the fissures have the following forms: (1) A single, straight, transverse line; (2) a flying-bird shape; (3) a V-shaped figure, sometimes crossed by a straight, longitudinal fissure; (4) an irregularly stellate arrangement of fissures. The hilum is eccentric from 0.3 to 0.17, usually 0.25, of the longitudinal axis.

The *lamellæ* are distinct, rather coarse lines. They are continuous, and are circular in form near the hilum, and in the rest of the grain they usually appear to be discontinuous and follow, in general, the form of the

outline of the grain. They often show some irregularities, the chief of which is a small notch or depression corresponding to the notch in the distal margin which is noted in some of the grains. There is frequently one coarse, moderately refractive lamella placed either at about half the distance between the hilum and the distal margin or very near the distal margin. The number of lamellæ counted on the larger grains varies from 10 to 20, usually 15.

In *size* the grains vary from the smaller which are 3 by 3μ, to the larger which are 30 by 16μ, in length and breadth. The common sizes are 22 by 14μ and 20 by 18μ.

Comparison of the *histologic properties* between *I. iberica* and *I. cengialti* shows:

Form. There are more compound grains and more aggregates than in *I. cengialti.* The compound grains belong to two types neither of which is the same as the one type seen in *I. cengialti.* In the first, 2 small grains, each consisting of a hilum and 1 or 2 lamellæ, are adherent and surrounded by 8 to 15 common secondary lamellæ, so that they are at the proximal end of a large elongated grain. In the second type, 2 or 3 small grains, if they are pyramidally arranged, each consisting of a hilum and 4 or 5 lamellæ, are surrounded by 1 or 2 common secondary lamellæ. The grains are not quite so regular in form, and the irregularities are due to the same causes as in *I. cengialti,* with the addition of one other—sharply defined, triangular depressions in the margin at the side, probably representing pressure facets. Elongated elliptical grains are more common and ovoid forms very much less common than in *I. cengialti.*

The *hilum* is more distinct than in *I. cengialti.* It is much less often fissured and the fissures have only the first two forms mentioned in that starch. The hilum is usually eccentric 0.15 of the longitudinal axis, 0.1 more than that of *I. cengialti.*

The *lamellæ* are less distinct, not quite so coarse, and more numerous, than in *I. cengialti.* Their general arrangement is the same as in that starch.

In *size* the grains are somewhat smaller though there is no very marked difference between the two starches in this respect. The common size is 20 by 14μ, 2μ shorter and the same breadth, and the same length and 4μ narrower, respectively, than the two common sizes of *I. cengialti.*

Polariscopic Properties.

The *figure* is distinct and usually well defined. The lines cross at a right angle or at an acute angle which varies widely in different grains. They are usually not bent, but not infrequently are bisected.

The *degree of polarization* varies from moderately high to high (value 60). There is usually but little variation in a given aspect of the same grain.

With *selenite* the quadrants are commonly clear-cut. They are very unequal in size but generally regular in form. The colors are, as a rule, pure and in an occasional grain they have a greenish tinge.

Comparison of the *polariscopic properties* between *I. iberica* and *I. cengialti* shows:

The *figure* is not quite so distinct and is not so well defined as in *I. cengialti.* The lines rarely cross at a right angle, but usually at an acute angle which does not vary so much in size in different grains as in *I. cengialti.* They are more often bent and less often bisected than in that starch.

The *degree of polarization* varies from low to high (value 50), 10 units lower than in *I. cengialti.* There is also more variation in a given aspect of the individual grains than in that starch.

With *selenite* the quadrants are not quite so clear-cut. They are as unequal in size, but are more often irregular in shape than in *I. cengialti.* The colors are usually not pure, while in *I. cengialti* they are pure.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate violet tinged with blue (value 45) and the color deepens rapidly until it is very deep and has assumed more of a bluish tint. With 0.125 per cent Lugol's solution, the grains all color a light violet and the color deepens rapidly until it is deep and has assumed more of a bluish tint. After heating in water until all the grains are completely gelatinized and then treating with a 2 per cent Lugol's solution the gelatinized *grains* all color a moderate indigo, and the *solution* a very deep indigo. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution most of the *grain-residues* are colored a light to moderately light indigo at their proximal ends only, the *capsules* reddish-violet and the *solution* a very deep indigo, deeper than after merely heating in water.

Comparison of the *iodine reactions* between *I. iberica* and *I. cengialti* shows:

With 0.25 per cent Lugol's solution, the grains all color a light to moderate violet tinged with blue (value 40), 5 units less than in *I. cengialti.* With 0.125 per cent Lugol's solution they are colored more lightly than with *I. cengialti.* After heating in water until the grains are completely gelatinized the grains are more and the solution less deeply colored. After boiling for 2 minutes and then treating with an excess of a 2 per cent Lugol's solution, the grain-residues are more often and less lightly colored; the capsules less deeply colored and the color is reddish violet instead of wine-red; the solution is very deeply colored, but not so deeply as in *I. cengialti.*

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes they are moderately colored (value 45). About half of the grains are moderately to deeply stained, and the other half light to moderately stained.

With *safranin* the grains all color very lightly at once, and in 30 minutes they are moderately colored (value 50) more than with gentian violet. A few of the grains are light to moderately colored, and the rest are moderately colored. There is much less variation than with gentian violet.

Comparison of the *aniline reactions* between *I. iberica* and *I. cengialti* shows:

With gentian violet the grains color moderate to lightly (value 40), 5 units less than with *I. cengialti.* There is much less variation between different grains than in *I. cengialti.*

With safranin the grains color moderately (value 45), 5 units less than in *I. cengialti.* There is less variation between different grains than in *I. cengialti.*

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 70° to 72° C., and of all is 74° to 76° C., mean 75° C.

Comparison of the *temperature reactions* between *I. iberica* and *I. cengialti* shows:

The temperature of gelatinization of all the grains is 71° to 72.5° C., mean 71.8° C., 3.2° C. less than that of the grains of *I. cengialti.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 1 minute. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 24 per cent of the grains and 34 per cent of the total starch in 15 minutes; in about 43 per cent of the grains and 52 per cent of the total starch in 30 minutes; in about 57 per cent of the grains and 62 per cent of the total starch in 45 minutes; in about 62 per cent of the grains and 66 per cent of the total starch in 60 minutes. (Chart D 400.)

The hilum becomes distinct, attended by the formation of a comparatively large bubble in most grains. The lamellæ are rather indistinct and are obliterated as gelatinization progresses. The grains become more refractive in appearance after the addition of the reagent, and the first portion of the grain to show this is a rather narrow band of material around the margin. Gelatinization begins at the corners of the distal margin and progresses smoothly toward the hilum and proximal end preceded by a pitted appearance in the ungelatinized material. It progresses usually with equal rapidity in the center and at the margins of the grains; but sometimes the interior of a grain is much less resistant than the margin, and gelatinization proceeds rapidly to the hilum in the interior of the grain, leaving the marginal material to be gelatinized later. The most resistant part of the grain and the last part to be gelatinized is always the proximal end. The gelatinized grains are large and have rather thick capsules, and are usually not very much distorted.

Comparison of the *chloral-hydrate* reactions between *I. iberica* and *I. cengialti* shows:

A bubble is formed as frequently as in *I. cengialti,* but is usually larger than in that starch. The lamellæ are also indistinct. The first part of the grain to become refractive after the addition of the reagent is a less narrow band of starch at the margin which is, however, not so refractive as the narrower band in *I. cengialti.* Gelatinization begins at the corners of the distal margin, but is preceded at these points by fissures which separate this portion from the rest of the grain. These are not seen in *I. cengialti.* The rest of the distal deposit assumes a pitted appearance and is invaded on either side by a longitudinal refractive fissure which extends about two-thirds of the way from the distal to the proximal end. Between these 2 fissures the starch becomes more and more refractive, is invaded by several longitudinal, refractive fissures, and is finally divided into granules of varying size and shape. In the meantime gelatinization spreads from the corners of the distal end along the distal margin and now spreads toward the proximal end. A similar process is never seen in *I. cengialti.* Gelatinization proceeds more rapidly in the interior than elsewhere, instead of with equal rapidity in both interior and margin as in most of the grains of *I. iberica.*

The gelatinized grains are as much swollen, have thin instead of rather thick capsules, and are very much more distorted than in *I. cengialti.*

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 18 per cent of the grains and 63 per cent of the total starch in 15 minutes; in about 41 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 45 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 90 per cent of the grains and in more than 99 per cent of the total starch in 60 minutes. (Chart D 401.)

The reaction with *pyrogallic acid* begins in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 45 per cent of the total starch in 15 minutes; in about 19 per cent of the grains and 71 per cent of the total starch in 30 minutes; in about 25 per cent of the grains and 78 per cent of the total starch in 45 minutes; in about 35 per cent of the grains and 84 per cent of the total starch in 60 minutes. (Chart D 402.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 12 per cent of the total starch in 5 minutes; in about 13 per cent of the grains and 66 per cent of the total starch in 15 minutes; in about 23 per cent of the grains and 73 per cent of the total starch in 30 minutes; in about 27 per cent of the grains and 83 per cent of the total starch in 45 minutes; in about 40 per cent of the grains and 90 per cent of the total starch in 60 minutes. (Chart D 403.)

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 64 per cent of the entire number of grains and 89 per cent of the total starch in 2 minutes; in about 93 per cent of the grains and 99 per cent of the total starch in 5 minutes. (Chart D 404.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 20 per cent of the entire number of grains and 60 per cent of the total starch in 5 minutes; in about 38 per cent of the grains and 82 per cent of the total starch in 15 minutes; in about 48 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about the same percentage of the grains and total starch in 45 minutes; in about the same percentage of the grains and 92 per cent of the total starch in 60 minutes. (Chart D 405.)

The hilum becomes very distinct, unattended by the formation of a bubble in any of the grains. The lamellæ are very distinct. Gelatinization begins at the hilum which swells slightly. Two extensively branching fissures extend from either side of the hilum nearly to the distal margin. The branches from these fissures divide the starch comprehended between them into many rather coarse refractive granules. From this point onward gelatinization progresses according to two methods. In the first method, which is seen in a majority of the grains, gelatinization begins at the distal margin and

then at the hilum and advances from these two points. The most resistant portion of the grain is usually a row of coarse granules which occur at a point one-half to two-thirds of the distance from the hilum to the distal margin, and less often just distal to the hilum. In the meantime the portion at the proximal end and sides nearby forms a lamellated and striated marginal band which presents a fringed appearance on its inner border due to its division into narrow spicules. This band grows progressively thinner and more nearly transparent and is finally gelatinized. The granules formed from the distal deposit as already described are usually the last part of the grain to be gelatinized and persist often for a long time. In the second method which is seen in a large minority of the grains, after the division of the distal material into granules gelatinization begins at the hilum which swells, and the distal portion begins to gelatinize from the hilum toward the distal end. Before the distal end is reached it is invaded at the margin by several longitudinal fissures which divide the starch and apparently hasten gelatinization. In the meantime the more resistant material at the proximal end and sides nearby forms a thick, indistinctly striated and lamellated marginal band around the inner border of which a number of granules formed from the starch immediately surrounding the hilum are arranged. This band becomes progressively thinner and more nearly transparent and is finally also gelatinized; the proximal margin being the last, except for the resistant granules scattered around the inner border, to be gelatinized.

The gelatinized grains are much swollen, have thin capsules, and are not greatly distorted. A few grains show partial or complete solution before gelatinization is complete.

Comparison of the *hydrochloric-acid* reactions between *I. iberica* and *I. cengialti* shows:

The hilum and lamellæ are not so distinct as in *I. cengialti*. Gelatinization in all the grains proceeds according to the method described for a moderate minority of the grains of *I. cengialti*. The only difference to be noted is that the material distal to the hilum and comprehended between the 2 fissures which proceed from either side of the hilum is divided into much finer and less refractive granules than in *I. cengialti*.

The gelatinized grains are as much swollen, and do not have such thin capsules as in *I. cengialti*. They are, however, somewhat more distorted than in that starch. There are more grains in which dissolution of the capsule at one point and partial or complete solution of the grain occurs than in *I. cengialti*.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 20 per cent of the entire number of grains and 75 per cent of the total starch in 5 minutes; in about 37 per cent of the grains and 85 per cent of the total starch in 15 minutes; in about 50 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 56 per cent of the grains and 93 per cent of the total starch in 45 minutes; in about 60 per cent of the grains and 94 per cent of the total starch in 60 minutes. (Chart D 406.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 14 per cent of the entire number of grains and 50 per cent of the total starch in 5 minutes; in about 41 per cent of the grains and 82 per cent of the total starch in 15 minutes; in about 50 per cent of the grains and 86 per cent of the total starch in 30 minutes; in about 66 per cent of the grains and 91 per cent of the total starch in 45 minutes; in about 66 per cent of the grains and 93 per cent of the total starch in 60 minutes. (Chart D 407.)

The hilum becomes very distinct, unattended by the formation of a bubble in any of the grains. The lamellæ also become very distinct and evidences of a lamellar structure remain visible throughout a greater part of the reaction. Gelatinization begins at the hilum, which enlarges slightly, and 2 fissures which are pre-existent in the untreated grain become very prominent and are seen to extend from either side of the hilum nearly to the distal margin. The starch which is included between these fissures becomes more refractive, and is divided into rather coarse, refractive granules by a number of fissures. The starch at the distal margin is then invaded by many longitudinal fissures and rapidly gelatinized. This is followed by gelatinization immediately distal to the hilum, and the two processes approach one another, a band of coarse granules midway between the hilum and the distal margin being the last of this portion of the grain to be gelatinized. The most resistant portion of the grain is usually formed at the proximal end and sides. This forms a striated and lamellated marginal band, which as the grain continues to swell, is gradually gelatinized, and loses its striated appearance, but retains some of its lamellated appearance until it is nearly completely gelatinized. In a few grains the proximal end is gelatinized immediately after the distal end, and the most resistant part of the grain is that midway between the hilum and the distal end.

The gelatinized grains are much swollen, have rather thick capsules, and are usually somewhat distorted.

Comparison of the *potassium-iodide* reactions between *I. iberica* and *I. cengialti* shows:

The hilum and lamellæ are not so distinct as in *I. cengialti*. Gelatinization proceeds in much the same manner as in *I. cengialti*, the differences noted being that the granules into which the portion of the grains included between the 2 pre-existing fissures is divided, are not so large and less refractive; the lamellated appearance does not remain so long visible in the marginal band at the proximal end and sides, and this band is distinctly striated, and there are fewer grains in which gelatinization begins first at the proximal end and subsequently at the distal end, than in *I. cengialti*. The gelatinized grains are as much swollen, but have thin instead of rather thick capsules, and are somewhat more distorted than in *I. cengialti*.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 39 per cent of the entire number of grains and 81 per cent of the total starch in 2 minutes; in about 66 per cent of the grains and 91 per cent of the total starch in 5 minutes; in about 72 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 75 per cent of the grains and 98 per cent of the total starch in 30 minutes. (Chart D 408.)

The reaction with *potassium sulphide* begins in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 3 per cent of

the total starch in 5 minutes; in about 1 per cent of the entire number of grains and 4 per cent of the total starch in 15 minutes; in about the same percentage of the grains and 5 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 10 per cent of the total starch in 45 minutes; in about the same percentage of both the grains and total starch in 60 minutes. (Chart D 409.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 28 per cent of the entire number of grains and 50 per cent of the total starch in 2 minutes; in about 46 per cent of the grains and 74 per cent of the total starch in 5 minutes; in about 65 per cent of the grains and 89 per cent of the total starch in 15 minutes; in about 73 per cent in 30 minutes; in about 77 per cent of the grains and 96 per cent of the total starch in 45 minutes; little if any advance in 60 minutes. (Chart D 410.)

The hilum becomes very distinct in all the grains. The lamellæ also become very distinct, and evidence of a lamellar structure is visible throughout the greater part of the reaction. Gelatinization begins at the hilum which swells somewhat and 2 fissures, which are usually existent in the untreated grain, become more distinct and are seen to extend from either side of the hilum nearly to the distal margin, and during the reaction these fissures give out many branches through the portion at the distal end of the grain. The starch comprehended between these fissures is divided into rather fine granules which are usually irregularly arranged. The distal end is now invaded from the margin by longitudinal fissures, and begins to gelatinize, instantly following this the hilum swells and the portion immediately distal to it is gelatinized. The 2 fissures approach one another and the last part of this portion of the grain to be gelatinized is midway between the hilum and the margin. The most resistant part of the grain is the material at the proximal end and sides nearby, which as the grain swells becomes finely striated and finally forms a distinctly striated and lamellated band at the margin. This is slowly gelatinized and loses its striated appearance but retains its lamellated character, until the end of the reaction is near. The gelatinized grains are moderately swollen, have rather thick capsules, and are moderately distorted.

Comparison of the *sodium-hydroxide* reactions between *I. iberica* and *I. cengialti* shows:

The hilum and lamellæ are not so distinct as in *I. cengialti.* Gelatinization progresses according to two methods, of which the one seen in the majority of the grains is very nearly the same as that described for all the grains of *I. cengialti.* The differences noted are: (1) The granules formed in the starch comprehended between the 2 fissures, which extend from the hilum to the distal margin, are finer and often regularly arranged in rows corresponding to the rows of the lamellæ; the lamellar structure of the marginal band at the proximal end and sides is not apparent for such a long time as in *I. cengialti;* (2) the second method is like the first except that the portion at the distal end and the part just distal to the hilum begin to gelatinize at nearly the same time and the most resistant part of this starch of the grain is that midway between the hilum and the distal end. The gelatinized grains are more swollen, have thin capsules, and are more distorted than in *I. cengialti.*

The reaction with *sodium sulphide* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 18 per cent of the grains and 48 per cent of the total starch in 15 minutes; in about 39 per cent of the grains and 60 per cent of the total starch in 30 minutes; in about 45 per cent of the grains and 66 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 411.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 44 per cent of the entire number of grains and 55 per cent of the total starch in 5 minutes; in about 90 per cent of the entire number of grains and 95 per cent of the total starch in 10 minutes; in about 99 per cent of the grains and in more than 99 per cent of the total starch in 15 minutes. (Chart D 412.)

The hilum becomes distinct, attended by the formation of a rather large bubble in a small majority of the grains. The lamellæ are at first indistinct, but later become more distinct. The grains become more refractive in appearance after the addition of the reagent, and the first part to show is a rather narrow band at the margin. Gelatinization is preceded by a distinctly pitted appearance of the surface of the grain at the distal end. It begins at the distal corners. From these points it spreads along the entire distal margin and then toward the hilum and proximal end, the material just preceding gelatinization being broken up into granules which are separated off and gelatinized. In the more resistant grains rather large, cup-shaped depressions are hollowed out which become deeper and deeper until the hilum is reached, and then in the rapid gelatinization which occurs are obliterated. The proximal end is usually gelatinized last, but in a moderate number of grains it begins to gelatinize immediately after the distal end and the most resistant portion of the grain is midway between the hilum and the distal margin.

The gelatinized grains are much swollen, have rather thick capsules, and are considerably distorted.

Comparison of the *sodium-salicylate* reaction between *I. iberica* and *I. cengialti* shows:

The hilum becomes distinct, attended by the formation of a smaller bubble in more grains than in *I. cengialti.* The lamellæ also are not so distinct as in that starch. The grains become more refractive in appearance after the addition of the reagent and the first part of the grain to show this change is a narrow band of material about the margin which is rather more refractive than in *I. iberica.* Gelatinization progresses in much the same way as in the less resistant grains of *I. cengialti,* the differences noted being that in many grains of *I. iberica* 2 longitudinal fissures proceed from the gelatinized distal margin nearly to the hilum and the material comprehended between them is gelatinized more rapidly than that at the margins. The formation of granules preceding gelatinization is also not seen in any of the grains. The proximal end gelatinizes immediately after the distal in fewer grains than in *I. cengialti.*

The gelatinized grains are as much swollen, have rather thin instead of rather thick capsules, and are more distorted than in *I. cengialti.*

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 41 per cent of the total starch in 15 minutes; in about 13 per cent of the grains and 59 per cent of the total starch in 30 minutes; in about 23 per cent of the grains and 63 per cent of the total starch in 45 minutes; in about 27 per cent of the grains and 68 per cent of the total starch in 60 minutes. (Chart D 413.)

The reaction with *uranium nitrate* begins in a few grains in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 10 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 20 per cent of the total starch in 30 minutes; in about 6 per cent of the grains and 33 per cent of the total starch in 45 minutes; in about 8 per cent of the grains and 36 per cent of the total starch in 60 minutes. (Chart D 414.)

The reaction with *strontium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 12 per cent of the total starch in 5 minutes; in about 24 per cent of the grains and 58 per cent of the total starch in 15 minutes; in about 38 per cent of the grains and 78 per cent of the total starch in 30 minutes; in about 41 per cent of the grains and 74 per cent of the total starch in 45 minutes; in about 47 per cent of the grains and 86 per cent of the total starch in 60 minutes. (Chart D 415.)

The reaction with *cobalt nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; in less than 0.5 per cent of the grains and 5 per cent of the total starch in 30 minutes; in less than 0.5 per cent of the grains and 6 per cent of the total starch in 45 minutes; in about 0.5 per cent of the grains and 7 per cent of the total starch in 60 minutes. (Chart D 416.)

The reaction with *copper nitrate* begins in a few grains in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 30 per cent of the total starch in 15 minutes; in about 10 per cent of the grains and 50 per cent of the total starch in 30 minutes; in about 18 per cent of the grains and 57 per cent of the total starch in 45 minutes; in about 24 per cent of the grains and 60 per cent of the total starch in 60 minutes. (Chart D 417.)

The reaction with *cupric chloride* begins in a few grains in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 15 per cent of the total starch in 15 minutes; in about 17 per cent of the grains and 55 per cent of the total starch in 30 minutes; in about 31 per cent of the grains and 62 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 68 per cent of the total starch in 60 minutes. (Chart D 418.)

The reaction with *barium chloride* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in about the same percentage of the grains and 2 per cent of the total starch in 30 minutes; in the same percentage of the grains and 3 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 5 per cent of the total starch in 60 minutes. (Chart D 419.)

The reaction with *mercuric chloride* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 0.5 per cent of the grains and 3 per cent of the total starch in 30 minutes; in about 1 per cent of the grains and 9 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 12 per cent of the total starch in 60 minutes. (Chart D 420.)

Iris dorak (Hybrid).

(Plate 18, fig. 108; Charts D 400 to D 420.)

Histologic Properties.

In *form* the grains are usually simple and isolated, but there are more compound grains and more aggregates than in *I. iberica*, and considerably more than in *I. cengialti.* The aggregates are usually small doublets of equal size, and the compound grains are of the same two types as are described under *I. iberica.* The grains are more irregular in form than in *I. iberica* and hence more irregular than in the other parent, and the irregularities are due to the same causes. The small, narrow notch in the middle of the distal margin is, however, much more common than in either parent. The conspicuous forms are: Elliptical with flattened distal end, which is not quite so common as in *I. iberica,* but more common than in *I. cengialti;* and ovoid, more common than in *I. iberica,* but less than in *I. cengialti.* The additional forms are nearly round, triangular with rounded angles, dome-shaped, lenticular, and club-shaped. The grains, as in the parents, are not flattened. In form *I. dorak* shows a somewhat closer relationship to *I. iberica* than to *I. cengialti.*

The *hilum* when not fissured is as distinct as in *I. iberica,* and is somewhat more often fissured than in that starch, but not nearly so often as in *I. cengialti.* When fissures occur they have the following forms: (1) A small, straight, transverse line; (2) a flying-bird; (3) 2 lines at an angle resembling a pair of dividers, and often crossed by a straight, transverse line; (4) rarely, an irregularly stellate arrangement of fissures. The hilum is eccentric 0.3 to 0.15, usually 0.21, which is 0.04 more eccentric than in *I. cengialti* and 0.06 less eccentric than in *I. iberica.* In the character of the hilum *I. dorak* shows a somewhat closer relationship to *I. iberica* than to *I. cengialti,* and in the degree of eccentricity to *I. cengialti.*

The *lamellæ* are somewhat more distinct and somewhat coarser than in *I. iberica* and have the same general arrangement as in those grains, but are usually not so irregular. The number counted on the larger grains varies from 10 to 20, usually 12, the same as in *I. iberica*, but less than in *I. cengialti*. In the character of the lamellæ *I. dorak* shows a somewhat closer relationship to *I. cengialti* than to *I. iberica*, but there are very few differences to be noted in the grains of the three starches.

In *size* the grains vary from the smaller which are 4 by 4μ, to the larger which are 36 by 16μ, in length and breadth. The common sizes are 20 by 11μ and 16 by 12μ. The grains are somewhat closer in size to *I. iberica* than to *I. cengialti*, but are, as a rule, somewhat smaller than in either parent.

Polariscopic Properties.

The *figure* is as distinct and as well defined as in *I. iberica;* somewhat less than in *I. cengialti*. The lines as in *I. iberica* usually cross at an acute angle which does not vary greatly in the different grains. They are somewhat more often bent and bisected than in *I. iberica*, and are very much more often bent than in *I. cengialti*.

The *degree of polarization* varies from low to high (value 50), the same as in *I. iberica* and 10 units lower than in *I. cengialti*. There is the same amount of variation in a given aspect of the individual grains as in *I. iberica*.

With *selenite* the quadrants are usually as clear-cut as in *I. iberica*, and less than in *I. cengialti*. They are unequal in size and as irregular in shape as in *I. iberica*. The colors are usually not pure as in that starch.

In the character of the figure, the degree of polarization, and the appearances with selenite *I. dorak* shows a closer relationship to *I. iberica* than to *I. cengialti*.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a light to moderate violet tinged with blue (value 40), the same as in *I. iberica* and 5 units less than in *I. cengialti*. With 0.125 per cent Lugol's solution the grains all color a light violet, the same as in *I. iberica* and lighter than in *I. cengialti*. After heating in water until all the grains are completely gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* are deeply or moderately deeply colored as in *I. iberica* and more than in *I. cengialti;* the *solution* deeply colored as in *I. iberica* and less than in *I. cengialti*. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, most of the *grain-residues* are not colored, a few are colored a very light indigo as in *I. iberica;* the *capsules* are all colored a deep wine-red as in *I. iberica;* and the *solution* a very deep indigo as in *I. iberica*. Qualitatively and quantitatively the reactions with iodine show a closer relationship to *I. iberica* than to *I. cengialti*.

Aniline Reactions.

With *gentian violet* the grains, as in the parents, stain very lightly at once, and in 30 minutes they are moderately stained (value 50), 5 units more than in *I. cengialti* and 10 units more than in *I. iberica*. There is a greater proportion of grains which are moderately to deeply stained than in *I. cengialti*.

With *safranin* the grains, as in the parents, stain very lightly at once, and in 30 minutes they are moderately stained (value 50), the same as in *I. cengialti*, and 5 units more than in *I. iberica*.

In the reaction with aniline stains *I. dorak* shows a closer relationship to *I. cengialti* than to *I. iberica*.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 68° to 70° C., and of all is 70° to 72° C., mean 71° C. The temperature of gelatinization of *I. dorak* is 0.8° C. less than that of *I. iberica* and 4° C. less than that of *I. cengialti*. It is therefore closer to *I. iberica* than to *I. cengialti*.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 1 minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 11 per cent of the grains and 17 per cent of the total starch in 15 minutes; in about 24 per cent of the grains and 33 per cent of the total starch in 30 minutes; in about 38 per cent of the grains and 44 per cent of the total starch in 45 minutes; in about 44 per cent of the grains and 50 per cent of the total starch in 60 minutes. (Chart D 400.)

The hilum, as in the parents, becomes distinct, attended by the formation of a bubble in the majority of the grains. The lamellæ, as in the parents, are not very distinct and soon become obliterated as the reaction progresses. The grain becomes more refractive after the addition of the reagent, and the first part to show this increased refractivity is the margin, around which, as in *I. iberica*, a rather broad, not very refractive band is formed. Gelatinization, as in the parents, begins at the corners of the distal margin, and is preceded by the appearance, as in *I. iberica*, of cracks or fissures, which separate the marginal material from the rest at these points. Gelatinization progresses as in *I. iberica*, except that the longitudinal fissures noted in those grains are more extensive, and more and larger granules are formed and separated off. There are also more grains than in *I. iberica* in which the proximal end begins to gelatinize after gelatinization has progressed about halfway from the distal end to the hilum. The process differs markedly from that in *I. cengialti* in which none of these phenomena is noted. The gelatinized grains are much swollen, have as thin capsules, and are as distorted as in *I. iberica*. In this reaction *I. dorak* shows qualitatively, a closer relationship to *I. iberica* than to *I. cengialti*.

The reaction with *chromic acid* begins in 30 seconds. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 29 per cent of the total starch in 5 minutes; in about 33 per cent of the grains and 86 per cent of the total starch in 15 minutes; in about 36 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 46 per cent of the grains and 97 per cent of the total starch in 45 minutes; in about 68 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 401.)

The reaction with *pyrogallic acid* begins in 30 seconds. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 20 per cent of the total starch in 5 minutes; in about 21 per cent of the

grains and 70 per cent of the total starch in 15 minutes; in about 54 per cent of the grains and 85 per cent of the total starch in 30 minutes; in about 63 per cent of the grains and 91 per cent of the total starch in 45 minutes; in about 64 per cent of the grains and 96 per cent of the total starch in 60 minutes. (Chart D 402.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 21 per cent of the entire number of grains and 65 per cent of the total starch in 5 minutes; in about 42 per cent of the grains and 78 per cent of the total starch in 15 minutes; in about 45 per cent of the grains and 81 per cent of the total starch in 30 minutes; in about 54 per cent of the grains and 84 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 89 per cent of the total starch in 60 minutes. (Chart D 403.)

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 72 per cent of the entire number of grains and 92 per cent of the total starch in 2 minutes; in about 95 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 404.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 33 per cent of the entire number of grains and 60 per cent of the total starch in 5 minutes; in about 47 per cent of the grains and 82 per cent of the total starch in 15 minutes; in about 60 per cent of the grains and 92 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes, respectively. (Chart D 405.)

The hilum is as distinct as in *I. iberica,* and the lamellæ are more distinct than in *I. iberica* and as distinct as in *I. cengialti.* Gelatinization is preceded by the same phenomena as in the parents and the fissures are somewhat more refractive and more extensive than in *I. iberica,* but less than in *I. cengialti,* and the distal material is less refractive and more finely granular than in either parent. Gelatinization progresses in general according to the method described under *I. iberica* and as observed in a minority of the grains of *I. cengialti,* except that there is more persistence of the granules than in *I. iberica,* and the marginal band at the proximal end and sides is striated as well as lamellated.

The gelatinized grains are large and have as thin capsules as in *I. iberica,* and the same amount of distortion as in that starch. The same approximate number of grains shows solution of the capsule at one point and partial or complete solution of the grain as in *I. iberica.*

In this reaction *I. dorak* shows qualitatively a closer relationship to *I. iberica* than to *I. cengialti.*

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 25 per cent of the entire number of grains and 66 per cent of the total starch in 5 minutes; in about 42 per cent of the grains and 80 per cent of the total starch in 15 minutes; in about 64 per cent of the grains and 86 per cent of the total starch in 30 minutes; in about the same percentage of the grains and total starch in 45 minutes; in about 66 per cent of the grains and 90 per cent of the total starch in 60 minutes. (Chart D 406.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 28 per cent of the entire number of grains and 75 per cent of the total starch in 5 minutes; in about 64 per cent of the grains and 89 per cent of the total starch in 15 minutes; in about the same percentage of the grains and 93 per cent of the total starch in 30 minutes; in about 68 per cent of the grains and 94 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 95 per cent of the total starch in 60 minutes. (Chart D 407.)

The hilum is as distinct as in *I. iberica* and the 2 refractive fissures usually already present in the untreated grain are not so distinct as in either parent, and are even more delicate and branching than in *I. iberica.* The lamellæ are somewhat less distinct than in *I. iberica,* and considerably less than in *I. cengialti.* Gelatinization, as in the parents, begins at the hilum and progresses as in *I. iberica,* except that there is more extensive fissuring, and more granulation, and also more grains in which gelatinization occurs first at the proximal end, but not so many as in *I. cengialti,* nor are there so many grains in which gelatinization occurs rapidly at the distal margin as in either parent. The marginal band formed at the proximal end and nearby sides of most of the grains is much more distinctly striated than in *I. iberica,* in this respect more closely resembling *I. cengialti.*

The gelatinized grains are much swollen and have rather thick capsules, in this respect closely resembling *I. cengialti,* but are more apt to be distorted, especially at the distal end, than in *I. iberica.*

In this reaction *I. dorak* shows qualitatively a somewhat closer relationship to *I. iberica* than to *I. cengialti.*

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 50 per cent of the entire number of grains and 77 per cent of the total starch in 2 minutes; in about 66 per cent of the grains and 90 per cent of the total starch in 5 minutes; in about 77 per cent of the entire number of grains and 95 per cent of the total starch in 15 minutes. (Chart D 408.)

The reaction with *potassium sulphide* begins in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 6 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 8 per cent of the total starch in 30 minutes; in about 3 per cent of the grains and 9 per cent of the total starch in 45 minutes; in about 4 per cent of the grains and 12 per cent of the total starch in 60 minutes. (Chart D 409.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 40 per cent of the entire number of grains and 65 per cent of the total starch in 2 minutes; in about 62 per cent of the grains and 80 per cent of the total starch in 5 minutes; in about 77 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 86 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 88 per cent of the grains and 96 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 410.)

The hilum and the lamellæ are more distinct than in *I. iberica,* and as distinct as in *I. cengialti.* As in both parents, 2 refractive fissures which are usually present in the untreated grain become more prominent, more extensive and more branched than in either parent, which is

an accentuation of a characteristic more definitely seen in *I. iberica* than in *I. cengialti.* Gelatinization, as in both parents, begins at the hilum which enlarges somewhat. The progress of gelatinization is according to two methods which are very nearly the same as in *I. iberica,* the differences noted are: That the starch comprehended between the 2 fissures proceeding from either side of the hilum is divided into larger and more distinct granules, in this resembling *I. cengiatti;* and the grains are more distinctly fissured at the distal end than in either parent, in this respect more closely resembling *I. iberica.*

The gelatinized grains are as much swollen as in *I. iberica,* but have less thin capsules and are somewhat less distorted than in that starch, but more than in *I. cengialti.*

In this reaction *I. dorak* shows qualitatively a somewhat closer relationship to *I. iberica* than to *I. cengialti.*

The reaction with *sodium sulphide* begins in a few grains immediately. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 27 per cent of the total starch in 5 minutes; in about 27 per cent of the grains and 47 per cent of the total starch in 15 minutes; in about 43 per cent of the grains and 60 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 66 per cent of the total starch in 45 minutes; in about 50 per cent of the grains and 70 per cent of the total starch in 60 minutes. (Chart D 411.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 37 per cent of the entire number of grains and 47 per cent of the total starch in 5 minutes; in about 85 per cent of the grains and 90 per cent of the total starch in 10 minutes; in more than 99 per cent of the grains and total starch in 15 minutes. (Chart D 412.)

The hilum becomes distinct, attended by the formation of a small bubble less frequently than in *I. iberica,* but more frequently than in *I. cengialti.* The lamellæ are not so distinct at any time as in either parent, and in this respect more nearly resemble *I. iberica* than *I. cengialti.* The grains, as in the parents, become more refractive in appearance after the reagent is added, and the first part to show this increased refractivity is a narrow band of starch around the margin, which is broader and more refractive than in either parent, and in this respect more closely resembling *I. iberica* than *I. cengialti.* Gelatinization, as in both parents, is preceded by a pitted appearance at the distal end, and begins at the corners of the distal margin. The process of gelatinization is the same as in *I. iberica,* but the proximal end of nearly the same number of grains as in *I. cengialti* and of more than in *I. iberica* is gelatinized when gelatinization has advanced halfway from the distal margin toward the hilum. The gelatinized grains are considerably swollen, and have as thick capsules and are as distorted as in *I. cengialti,* but the capsules are thicker and the grains are less distorted than in *I. iberica.* In this reaction *I. dorak* shows qualitatively a somewhat closer relationship to *I. iberica* than to *I. cengialti.*

The reaction with *calcium nitrate* begins in a few grains immediately. Complete gelatizination occurs in less than 0.5 per cent of the entire number of grains and 14 per cent of the total starch in 5 minutes; in about 8 per cent of the grains and 28 per cent of the total starch in 15 minutes; in about 16 per cent of the grains and 48 per cent of the total starch in 30 minutes; in about 28 per cent of the grains and 60 per cent of the total starch in 45 minutes; in about 36 per cent of the grains and 68 per cent of the total starch in 60 minutes. (Chart D 413.)

The reaction with *uranium nitrate* begins in a few grains in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 18 per cent of the total starch in 15 minutes; in about 7 per cent of the grains and 32 per cent of the total starch in 30 minutes; in about 14 per cent of the grains and 39 per cent of the total starch in 45 minutes; in about 21 per cent of the grains and 46 per cent of the total starch in 60 minutes. (Chart D 414.)

The reaction with *strontium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 20 per cent of the total starch in 5 minutes; in about 27 per cent of the grains and 55 per cent of the total starch in 15 minutes; in about 41 per cent of the grains and 65 per cent of the total starch in 30 minutes; in about 48 per cent of the grains and 72 per cent of the total starch in 45 minutes; in about 58 per cent of the grains and 79 per cent of the total starch in 60 minutes. (Chart D 415.)

The reaction with *cobalt nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and 3 per cent of the total starch in 15 minutes; in about 0.5 per cent of the grains and 4 per cent of the total starch in 30 minutes; in about 1 per cent of the grains and 5 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 6 per cent of the total starch in 60 minutes. (Chart D 416.)

The reaction with *copper nitrate* begins in a few grains in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 20 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 28 per cent of the total starch in 15 minutes; in about 9 per cent of the grains and 50 per cent of the total starch in 30 minutes; in about 12 per cent of the grains and 55 per cent of the total starch in 45 minutes; in about 25 per cent of the grains and 58 per cent of the total starch in 60 minutes. (Chart D 417.)

The reaction with *cupric chloride* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 15 per cent of the total starch in 5 minutes; in about 15 per cent of the grains and 56 per cent of the total starch in 15 minutes; in about 20 per cent of the grains and 64 per cent of the total starch in 30 minutes; in about 25 per cent of the grains and 66 per cent of the total starch in 45 minutes; in about 28 per cent of the grains and 70 per cent of the total starch in 60 minutes. (Chart D 418.)

The reaction with *barium chloride* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and

1 per cent of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 6 per cent of the total starch in 30 minutes; in about 2 per cent of the grains and 8 per cent of the total starch in 45 minutes; in about 3 per cent of the grains and 12 per cent of the total starch in 60 minutes. (Chart D 419.)

The reaction with *mercuric chloride* begins in a few grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 11 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 17 per cent of the total starch in 30 minutes; in about 5 per cent of the grains and 21 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 22 per cent of the total starch in 60 minutes. (Chart D 420.)

32. Starches of Iris cengialti, I. pallida queen of may, and I. mrs. allan grey.

Starch of *Iris cengialti* (seed parent) is described in pages 647 to 652.

I. pallida queen of may (Pollen Parent).

(Plate 19, fig. 110; Charts D 421 to D 441.)

Histologic Properties.

In *form* the grains are usually simple and isolated, but both compound grains and aggregates occur in moderate numbers. The compound grains belong to two types: (1) 2 small grains are adherent and surrounded by a number of common secondary lamellæ and located either at the proximal end or in the middle of a large grain (the exact number of lamellæ often can not be determined); (2) 2 or 3 grains are adherent to a larger grain and all surrounded by one common layer of starch, forming a very irregular compound grain. The aggregates are usually doublets of equal size, but sometimes consist of 3 or 4 grains adherent to one another in irregular manner. The grains are often irregular in form and the irregularities are due to the following causes: (1) a secondary set of lamellæ usually situated near the proximal end or middle of the grain whose longitudinal axis is at an angle, usually a right angle, with that of the primary set; (2) a deviation of the axis with a consequent bending of the grain in the middle or near the distal end; (3) shallow depressions and elevations of the surface and margin, often consisting of 1, 2, or 3 regular enlargements and constrictions of the grain throughout its length; (4) rarely a small protuberance, usually at the distal end; (5) rarely a deep notch in the distal margin. The conspicuous forms are elongated elliptic and elongated ovoid, both with flattened distal ends, and pyriform. The additional forms are club-, rod-, finger-, boot-, and hammer-shaped, and nearly round. The grains are not flattened.

The *hilum* is usually a moderately distinct, round spot. It is seldom fissured and the fissures are not deep nor extensive. They have the following forms: (1) A short, straight, transverse line; (2) a flying-bird figure. The hilum is eccentric from 0.4 to 0.25, commonly 0.29, of the longitudinal axis.

The *lamellæ* are usually moderately distinct and rather coarse. Near the hilum they are generally not so distinct nor so coarse as in the rest of the grain. They are continuous except near the margin and usually have the form of the outline of the grain, except that they have a flattened portion in the longitudinal axis of the grain. There are often 2 or 3 especially coarse and distinct lamellæ situated respectively one-half, two-thirds, and three-fourths of the distance from the hilum to the distal margin. The number counted on some of the larger grains varies from 8 to 20, usually 15.

In *size* the grains vary from the smaller which are 4 by 4μ, to the larger which are 24 by 10μ, in length and breadth. The common sizes are 14 by 6μ and 14 by 9μ.

Comparison of the *histologic properties* between *I. cengialti* and *I. pallida queen of may* shows:

There are fewer compound grains and aggregates. The compound grains consist of an irregular mass of 3 to 5 or 6 component grains surrounded by 1 common layer of starch. The aggregates are doublets of equal-sized grains. The grains are not so irregular as in *I. pallida queen of may,* and the irregularities are due to the same causes, but secondary sets of lamellæ and deviation of the longitudinal axis are not nearly so common as in that starch. The conspicuous forms are not very different, but are more rounded and not so slender as in *I. pallida queen of may.*

The *hilum* when not fissured is more distinct. It is usually fissured, much more often and also much more deeply and more extensively than in *I. pallida queen of may.* The fissures have the following forms of which the first two are the same as in *I. pallida queen of may:* (1) A single, straight line; (2) a flying-bird figure; (3) a V-shaped figure sometimes crossed by a straight, transverse fissure; (4) an irregularly stellate arrangement of fissures. The hilum is usually more eccentric 0.04 of the longitudinal axis than in *I. pallida queen of may.*

The *lamellæ* are generally not so distinct and are coarser than in *I. pallida queen of may.* Usually only 1 very coarse lamella is seen at half the distance from the hilum to the margin. There is also often a notch in the outline of the lamellæ, as a rule, corresponding to a notch in the distal margin, which is not seen in *I. pallida queen of may.*

In *size* the grains are larger than those of *I. pallida queen of may.* The large grains are 6μ longer and 6μ broader than those of *I. pallida queen of may,* and the common-sized grains are 8μ longer and 8 to 6μ broader than those of *I. pallida queen of may.*

Polariscopic Properties.

The *figure* is usually moderately distinct and well defined. The lines usually cross at a very acute angle which does not vary greatly in different grains. They are very often much bent and often also bisected. The figure moderately often has the form of a compound hyperbola or of a long line bisected at both ends.

The *degree of polarization* varies from low to high (value 50). In most of the grains it is moderate and in a few it is low, and in the rest it is moderately high and high. There is some variation in a given aspect of the individual grains.

With *selenite* the quadrants are moderately clear-cut. They are unequal in size and often very irregular in shape. The colors are usually not pure, the yellow being more often impure than the blue.

Comparison of the *polariscopic properties* between *I. cengialti* and *I. pallida queen of may* shows:

The figure is more distinct and well defined than in *I. pallida queen of may.* The lines cross at a right angle or at an acute angle which varies much more widely in size in different grains than in *I. pallida queen of may.* They are also less often bent and bisected than in that starch. The figure is less often in the form of a conjugate hyperbola or of a long line bisected at both ends.

The *degree of polarization* is (60) 10 units higher than in *I. pallida queen of may,* as there are more grains in which it is moderately high to high than in that starch. There is less variation in a given aspect of the same grain.

With *selenite* the quadrants are more clear-cut and less irregular in form than in *I. pallida queen of may.* The colors are also more often pure than in that starch.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a light to moderate violet tinged with blue (value 35). The color deepens with moderate rapidity until it is very deep, at the same time assuming more of a bluish tint. With 0.125 per cent Lugol's solution the grains all color a very light violet. The color deepens with moderate rapidity until it is deep, and has assumed a bluish tint. After heating in water until all the grains are completely gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* all color a moderate, moderately deep, or deep indigo, and the *solution* a deep indigo. If the preparation is boiled for 2 minutes and then treated with a 2 per cent Lugol's solution, most of the *grain-residues* color a very light indigo; the *capsules* a deep wine-red; and the *solution* a very deep indigo.

Comparison of the *iodine reactions* between *I. cengialti* and *I. pallida queen of may* shows:

With 0.25 per cent Lugol's solution the grains are colored a moderate violet tinged with blue (value 45), 5 units more than in *I. pallida queen of may.* With 0.125 per cent Lugol's solution the grains all color a light violet more than in *I. pallida queen of may.* After heating in water until the grains are all gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized grains all color a moderate indigo, less than in *I. pallida queen of may;* and the solution a very deep indigo, more than in *I. pallida queen of may.* If the preparation is boiled for 2 minutes and then treated with a 2 per cent Lugol's solution, the grain-residues are colored a light to moderately light indigo, more than in *I. pallida queen of may;* the capsules a reddish violet instead of a deep wine-red as in *I. pallida queen of may;* and the solution a very deep indigo as in *I. pallida queen of may.*

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes they are moderately colored (value 48). Many of the grains are moderately deeply colored but the majority are light to moderately colored.

With *safranin* the grains all color very lightly at once, and in 30 minutes they are moderately colored (value 52) more than with gentian violet. Many of the grains are moderately deeply colored, but the majority are light to moderately colored.

Comparison of the *aniline reactions* between *I. cengialti* and *I. pallida queen of may* shows:

With gentian violet the grains are colored (value 45) 3 units less than in *I. pallida queen of may.*

With safranin the grains are colored (value 50) 2 units less than in *I. pallida queen of may.*

There is very little difference to be noted in the reactions of the two starches with aniline stains.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 71° to 73° C., and of all is 75° to 75.8° C., mean 75.4° C.

Comparison of the *temperature reactions* between *I. cengialti* and *I. pallida queen of may* shows:

The temperature of gelatinization is 74° to 76° C., mean 75° C. The temperature of gelatinization of the majority of the grains of *I. pallida queen of may* is 1° C. higher and of all of the grains 0.4° C. higher than that of *I. cengialti.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 1 minute. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 50 per cent of the grains and 55 per cent of the total starch in 15 minutes; in about 68 per cent of the grains and 72 per cent of the total starch in 30 minutes; in about 78 per cent of the grains and 83 per cent of the total starch in 45 minutes; in about 81 per cent of the grains and 84 per cent of the total starch in 60 minutes. (Chart D 421.)

The hilum becomes distinct, attended by the formation of a bubble in most of the grains. The lamellæ are usually not visible, but in some grains may be indistinctly seen. The grains become more refractive after the addition of the reagent, and the first part to show this change is a rather narrow band of starch at the margin which becomes moderately refractive. Gelatinization begins at the corners of the distal margin and spreads from these points across the distal margin. Two longitudinal fissures appear and extend about half the distance from the distal margin to the hilum, and the portion marginal to the fissures is more rapidly gelatinized than that comprehended between them. After the ends of the fissures are passed in the progress of gelatinization the central and marginal portions of the grain gelatinize with equal rapidity. When the hilum is reached it swells suddenly and rapidly, and the bubble if present swells also, then shrinks, and finally disappears. The starch at the proximal end which is the last to be gelatinized is gelatinized rapidly after this swelling of the hilum.

The gelatinized grains are much swollen, have rather thick capsules, and are greatly distorted especially at the distal end.

Comparison of the *chloral-hydrate* reactions between *I. cengialti* and *I. pallida queen of may* shows:

The hilum becomes distinct, attended by the formation of a bubble in a somewhat smaller majority of the

grains than in *I. pallida queen of may.* The lamellæ are rather indistinct, but are visible in many more grains than in *I. pallida queen of may.* The grains become more refractive after the addition of the reagent, and the first portion of the grain to show this is a rather narrow band of starch around the margin, which is, however, not so narrow and much more refractive than in *I. pallida queen of may.* Gelatinization as in *I. pallida queen of may* begins at the corners of the distal margin and spreads all along the distal margin from these points, but unlike in that starch it proceeds smoothly without the appearance of longitudinal fissures extending toward the hilum from the distal end; also it usually proceeds with equal rapidity along the margin and in the interior of the grains, but in some grains it proceeds more rapidly in the interior than along the margin. This is not seen in *I. pallida queen of may.*

The gelatinized grains are as much swollen, have somewhat less thick capsules, and are not so much distorted as in *I. pallida queen of may.*

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 11 per cent of the grains and 40 per cent of the total starch in 15 minutes; in about 24 per cent of the grains and 81 per cent of the total starch in 30 minutes; in about 49 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 68 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 422.)

The reaction with *pyrogallic acid* begins in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 30 per cent of the total starch in 15 minutes; in about 16 per cent of the grains and 67 per cent of the total starch in 30 minutes; in about 28 per cent of the grains and 84 per cent of the total starch in 45 minutes; in about 36 per cent of the grains and 92 per cent of the total starch in 60 minutes. (Chart D 423.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 9 per cent of the total starch in 5 minutes; in about 21 per cent of the grains and 62 per cent of the total starch in 15 minutes; in about 34 per cent of the grains and 70 per cent of the total starch in 30 minutes; in about 39 per cent of the grains and 79 per cent of the total starch in 45 minutes; in about 42 per cent of the grains and 81 per cent of the total starch in 60 minutes. (Chart D 424.)

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 59 per cent of the entire number of grains and 89 per cent of the total starch in 2 minutes; in about 90 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 425.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 24 per cent of the entire number of grains and 64 per cent of the total starch in 5 minutes; in about 32 per cent of the grains and 80 per cent of the total starch in 15 minutes; in about 44 per cent of the grains and 84 per cent of the total starch in 30 minutes; in about the same percentage of both the grains and total starch in 45 minutes; in about the same percentage of the grains and 86 per cent of the total starch in 60 minutes. (Chart D 426.)

The hilum becomes distinct in all the grains. The lamellæ also are very distinct. Two fissures which extend from the hilum to the distal margin and which pre-exist in the untreated grain, become more distinct, and the starch included between them is divided by rather indistinct fissures into large irregular granules. Gelatinization begins at the distal end of the grain and advances toward the hilum. As the grain swells the rather indistinct, irregular fissures become more distinct and separate the granules more widely. The portion at the proximal margin and sides, which is very definitely separated from the other part of the grain, forms a homogeneous-looking band at the margin. This, as the grain continues to swell, is often invaded by short straight cracks proceeding from the hilum at regular intervals. After the starch comprehended between the 2 original fissures is completely gelatinized, this marginal band grows progressively thinner and more nearly transparent until it is completely gelatinized and only the capsule remains. The gelatinized grains are much swollen, have rather thin capsules, and are not greatly distorted.

Comparison of the *hydrochloric-acid* reactions between *I. cengialti* and *I. pallida queen of may* shows:

The hilum and lamellæ are somewhat more distinct than in *I. pallida queen of may.* Gelatinization begins at the hilum and progresses according to two methods. The first, which is seen in a majority of the grains, differs from that described for all the grains of *I. pallida queen of may* in the following points: Gelatinization begins at the distal margin, and then at the hilum, and the most resistant portion, that which is comprehended between the two pre-existing fissures from the hilum, is midway between the hilum and the distal end, instead of just at the hilum, as in *I. pallida queen of may;* the granules into which this material is originally divided are finer and less irregular in arrangement than those of *I. pallida queen of may.* In the second method the difference noted is that gelatinization begins at the hilum and proceeds from there to the distal margin. In both methods the marginal band at the proximal end and sides nearby is indistinctly striated and lamellated instead of being homogeneous in appearance as in *I. pallida queen of may.*

The gelatinized grains are more swollen, have somewhat less thin capsules, and are somewhat less distorted, than in *I. pallida queen of may.*

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 24 per cent of the entire number of grains and 72 per cent of the total starch in 5 minutes; in about 44 per cent of the grains and 86 per cent of the total starch in 15 minutes; in about 51 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 91 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 93 per cent of the total starch in 60 minutes. (Chart D 427.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 10 per cent of the entire number of grains and 30 per cent of

the total starch in 5 minutes; in about 28 per cent of the grains and 75 per cent of the total starch in 15 minutes; in about 47 per cent of the grains and 83 per cent of the total starch in 30 minutes; in about 50 per cent of the grains and 88 per cent of the total starch in 45 minutes; in about 55 per cent of the grains and 90 per cent of the total starch in 60 minutes. (Chart D 478.)

The hilum becomes very distinct in all the grains. The lamellæ also are distinct. Two fissures which pre-exist in the untreated grain become more conspicuous and are seen to extend from the hilum to the distal margin. The starch comprehended between these two fissures is divided by irregular fissures into a number of irregular, refractive granules. Gelatinization follows two methods. In the great majority of the grains the material at the distal end begins to gelatinize first and gelatinization proceeds from this point to the hilum, the fissures and the granules becoming more distinct as the grain swells. The starch at the proximal margin and sides forms a homogeneous-looking band as the grain swells and this is the most resistant part of the grain. It gradually becomes thinner and more nearly transparent until it is completely gelatinized. In the second method, the hilum swells and the granular starch comprehended between the 2 original fissures is gelatinized at the hilum and then gradually toward the distal end. The material at the proximal end and sides forms a homogeneous-looking, refractive band at the margin which gradually grows thinner and more nearly transparent until it is gelatinized and only the capsule remains.

The gelatinized grains are moderately swollen, have rather thick capsules, and are not greatly distorted.

Comparison of the *potassium-iodide* reactions between *I. cengialti* and *I. pallida queen of may* shows:

The hilum is as distinct and the lamellæ are somewhat more distinct than in *I. pallida queen of may.* Gelatinization proceeds according to two methods. The first, which is seen in a large majority of the grains, differs from that described for a very large majority of the grains of *I. pallida queen of may* in that gelatinization begins at the distal end and then at the hilum and the two processes approach one another, the most resistant part of this portion of the grain being about half the distance between the hilum and the distal end. The second method, which is seen in more grains than in *I. pallida queen of may,* is the same as the second method described in that grain. In all the grains the granules formed previous to gelatinization are finer and arranged in rows corresponding to the rows of the lamellæ, instead of irregularly as in *I. pallida queen of may.* The gelatinized grains are moderately swollen and have somewhat thicker capsules, but are no more distorted, than in that starch.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 40 per cent of the entire number of grains and 75 per cent of the total starch in 2 minutes; in about 51 per cent of the grains and 89 per cent of the total starch in 5 minutes; in about 66 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 68 per cent of the grains and 96 per cent of the total starch in 30 minutes. (Chart D 429.)

(NOTE.—The grains are quickly gelatinized with the exception of a narrow band at the proximal end and sides nearby and a few scattered entire grains. The time reactions are not carried beyond the 95 per cent of the total starch when this is reached in 15 minutes, since this is considered as practically the end of the reaction. The ungelatinized portion after this period of time is generally very slowly affected, as determined by an observation on several of the starches. In the group *I. cengialti–I. pallida queen of may–I. mrs. alan grey,* the observations up to 30 minutes are noted because the starch of *I. mrs. alan gray* is comparatively slow; after 30 minutes the gelatinization in this starch is very slow.)

The reaction with *potassium sulphide* begins in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 6 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 10 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes. (Chart D 430.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 25 per cent of the entire number of grains and 58 per cent of the total starch in 2 minutes; in about 41 per cent of the grains and 75 per cent of the total starch in 5 minutes; in about 61 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 75 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 78 per cent of the grains and 95 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 431.)

The hilum becomes distinct in all the grains. The lamellæ also are very distinct. Two fissures which pre-exist in the untreated grain become more distinct and are clearly seen to extend from the hilum to the distal margin. The starch comprehended between them is divided by many fine fissures into a number of fine refractive granules. Gelatinization begins, usually, at the distal end and then, quickly, at the hilum and the two processes approach one another; the most resistant part of this portion of the grain being a row of rather coarse granules, situated at about half the distance from the hilum to the distal margin. The portion at the proximal margin and sides meanwhile forms a homogeneous-looking refractive band at the margin which gradually grows thinner and more nearly transparent until it is completely gelatinized and only the capsule remains.

The gelatinized grains are much swollen, have moderately thick capsules, and are considerably distorted especially at the distal end.

Comparison of the *sodium-hydroxide* reactions between *I. cengialti* and *I. pallida queen of may* shows:

The hilum and lamella are somewhat more distinct than in *I. pallida queen of may.* Gelatinization usually begins at the distal end and then at the proximal as in *I. pallida queen of may;* but in a number of grains it begins at the hilum and proceeds to the distal end. The starch comprehended between the 2 pre-existing fissures which extend from the hilum to the distal end is divided into finer granules than in *I. pallida queen of may* and these are often arranged in rows corresponding to the rows of lamellæ, instead of irregularly as in *I. pallida queen of may.*

The gelatinized grains are much swollen, have thicker capsules, and are not quite so much distorted as in *I. pallida queen of may.*

The reaction with *sodium sulphide* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 12 per cent of the total starch in 5 minutes; in about 16 per cent of the grains and 50 per cent of the total starch in 15 minutes; in about 37 per cent of the grains and 53 per cent of the total starch in 30 minutes; in about 44 per cent of the grains and 59 per cent of the total starch in 45 minutes; in about 44 per cent of the grains and 62 per cent of the total starch in 60 minutes. (Chart D 432.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 73 per cent of the entire number of grains and 80 per cent of the total starch in 5 minutes; in about 98 per cent of the grains and in more than 99 per cent of the total starch in 10 minutes. (Chart D 433.)

The hilum becomes distinct, attended by the formation of a bubble in most of the grains. The lamellæ are usually not visible, but in some grains they may be indistinctly seen. The grains become somewhat more refractive after the addition of the reagent, and the first part to show this change is a narrow band of starch at the margin which becomes moderately refractive. Gelatinization begins at the corners of the distal margin and spreads along the distal margin from these points. Two longitudinal fissures appear, in most of the grains, which extend from the distal margin half-way to the hilum. The portion marginal to these fissures is more rapidly gelatinized than the part of the grain between them and not until the parts at the ends of the fissures are in the process of gelatinization do all parts of the grain gelatinize with equal speed. When the hilum is reached it swells and the bubble if present also swells at first, then shrinks, and finally disappears. The proximal starch, which is the last to be gelatinized, is gelatinized rather quickly, following the swelling of the hilum. In a few grains the proximal end is gelatinized immediately after the distal end and in such grains the last portion of the grain to be gelatinized is just distal to the hilum. The gelatinized grains are much swollen, have rather thin capsules, and are very much distorted.

Comparison of the *sodium-salicylate* reactions between *I. cengialti* and *I. pallida queen of may* shows:

The hilum becomes distinct, attended by the formation of a bubble in a somewhat smaller majority of the grains than in *I. pallida queen of may.* The lamellæ which are at first indistinct, later become moderately distinct. In *I. pallida queen of may* they are usually invisible. The grains become more refractive after the addition of the reagent and the first part of the grain to be so affected is a rather narrow band at the margin which is not so narrow and more refractive than in *I. pallida queen of may.* Gelatinization is not accompanied by the appearance of 2 fissures as in *I. pallida queen of may,* but is preceded by a pitted appearance of the ungelatinized material and by a formation and separation of granules, neither of which phenomena is seen in *I. pallida queen of may.* The proximal end begins to gelatinize immediately after the distal end in more grains in *I. pallida queen of may.*

The gelatinized grains are as much swollen, the capsules are not so thin, and they are not quite so much distorted as in *I. pallida queen of may.*

The reaction with *calcium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 45 per cent of the total starch in 15 minutes; in about 10 per cent of the grains and 50 per cent of the total starch in 30 minutes; in about 15 per cent of the grains and 56 per cent of the total starch in 45 minutes; in about 25 per cent of the grains and 60 per cent of the total starch in 60 minutes. (Chart D 434.)

The reaction with *uranium nitrate* begins in a few grains in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 0.5 per cent of the grains and 9 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 18 per cent of the total starch in 30 minutes; in about 8 per cent of the grains and 25 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 29 per cent of the total starch in 60 minutes. (Chart D 435.)

The reaction with *strontium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 11 per cent of the grains and 46 per cent of the total starch in 15 minutes; in about 27 per cent of the grains and 54 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 63 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 68 per cent of the total starch in 60 minutes. (Chart D 436.) The margin of the grains of this species is very resistant.

The reaction with *cobalt nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in less than 0.5 per cent of the grains and 2 per cent of the total starch in 30 minutes; slight progress in 45 minutes; in about 0.5 per cent of the grains and 3 per cent of the total starch in 60 minutes. (Chart D 437.)

The reaction with *copper nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 12 per cent of the total starch in 5 minutes; in the same percentage of the grains and 25 per cent of the total starch in 15 minutes; in about 6 per cent of the grains and 36 per cent of the total starch in 30 minutes; in about 12 per cent of the grains and 48 per cent of the total starch in 45 minutes; in about 20 per cent of the grains and 51 per cent of the total starch in 60 minutes. (Chart D 438.)

The reaction with *cupric chloride* begins in a few grains in 30 seconds. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 19 per cent of the total starch in 15 minutes; in about 12 per cent of the grains and 48 per cent of the total starch in 30 minutes; in about

18 per cent of the grains and 60 per cent of the total starch in 45 minutes; in about 21 per cent of the grains and 63 per cent of the total starch in 60 minutes. (Chart D 439.)

The reaction with *barium chloride* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of both the grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 0.5 per cent of the grains and 3 per cent of the total starch in 30 minutes; in about 1 per cent of the grains and 4 per cent of the total starch in 45 minutes; in about 1 per cent of the grains and 5 per cent of the total starch in 60 minutes. (Chart D 440.)

The reaction with *mercuric chloride* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in about 0.5 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about the same percentage of the grains and 9 per cent of the total starch in 30 minutes; in about 1 per cent of the grains and 10 per cent of the total starch in 45 minutes; in about 2 per cent of the grains and 14 per cent of the total starch in 60 minutes. (Chart D 441.)

Iris mrs. alan grey (Hybrid).

(Plate 19, fig. 111; Charts D 421 to D 441.)

Histologic Properties.

In *form* the grains are usually simple and isolated. There are, however, as many compound grains and aggregates as in *I. pallida queen of may*, and both belong to the same types which are described under that starch. The grains are more regular in form than in either parent, in this respect more closely resembling *I. cengialti* than *I. pallida queen of may*. The irregularities which occur are due to the same causes, and in the same order of frequency of occurrence as in *I. cengialti*. The conspicuous forms are elongated and broad elliptical with flattened distal end, ovoid, and nearly round. The additional forms are boot-shaped, rod-shaped, and pyriform. The grains are not flattened.

In form the grains of *I. mrs. alan grey* show, on the whole, a somewhat closer relationship to *I. cengialti* than to *I. pallida queen of may*. The three starches resemble one another closely.

The *hilum* is moderately distinct and is even less often fissured than in *I. pallida queen of may*. The fissures have the same forms as in that starch. The hilum is eccentric from 0.4 to 0.1, usually 0.19, of the longitudinal axis.

In the character of the hilum *I. mrs. alan grey* shows a closer resemblance to *I. pallida queen of may*. The hilum is more eccentric (0.1 of the longitudinal axis) than *I. pallida queen of may*, and is still more eccentric (0.06 of the longitudinal axis) than in *I. cengialti*, therefore closer to *I. pallida queen of may*.

The *lamellæ* are less distinct than in either parent, in this resembling *I. cengialti* more closely than *I. pallida queen of may*. Otherwise they are the same as in *I. cengialti*. The entire number on the grains can not be determined.

In *size* the grains vary from the smaller grains which are 3 by 3μ, to the larger which are 22 by 10μ, in length and breadth. The common sizes are 10 by 8μ and 10 by 6μ. *I. mrs. alan grey* is smaller than either parent, but is closer to *I. pallida queen of may* than to *I. cengialti*. The large-sized grains are 2μ shorter but no narrower than those of *I. pallida queen of may* and 8μ shorter and 6μ narrower than those of *I. cengialti*. The common sizes are 4μ shorter but are 2μ wider than those of *I. mrs. alan grey*, and are 12μ shorter and 4μ narrower than those of *I. cengialti*.

Polariscopic Properties.

The *figure* is not so distinct nor so well defined as in either parent, but in this respect resembles *I. pallida queen of may* more closely than *I. cengialti*. The lines cross at right angles as in some grains of *I. pallida queen of may*, or at a very acute angle which, as in *I. pallida queen of may*, does not vary much in size in different grains. They are as much bent and as often bisected as in *I. pallida queen of may*. The figure is as frequently in the form of a conjugate hyperbola or of a long line bisected at both ends as in that starch.

The *degree of polarization* varies from low to high (value 45), 5 units less than in *I. pallida queen of may* and 15 units less than in *I. cengialti*. There are fewer grains in which it is high, and more in which it is low or low to moderate, than in either parent. There is usually some variation in a given aspect of an individual grain.

With *selenite* the quadrants are not so clear-cut as in either parent, but are closer in this respect to *I. pallida queen of may* than to *I. cengialti*. They are as irregular in form as in *I. pallida queen of may*. The colors are somewhat more often impure than in either parent.

In the character of the figure, the degree of polarization, and the appearance with selenite *I. mrs. alan grey* shows a closer relationship to *I. pallida queen of may* than to *I. cengialti*.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate violet tinged with blue (value 50), 5 units more than in *I. cengialti* and 15 units more than in *I. pallida queen of may*. With 0.125 per cent Lugol's solution the grains all color a light violet, more than in either parent but closer to *I. cengialti* than to *I. pallida queen of may*. The qualitative reactions are closer to those of *I. cengialti*.

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in half an hour they are light to moderately colored (value 40), 5 units less than in *I. cengialti* and 8 units less than in *I. pallida queen of may*.

With *safranin* the grains all color very lightly at once, and in half an hour they are moderately colored (value 45), 5 units less than in *I. cengialti* and 7 units less than in *I. pallida queen of may*.

In the reactions with aniline stains *I. mrs. alan grey* shows a closer relationship to *I. cengialti* than to *I. pallida queen of may*.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 69° to 70° C., and of all is 73° to 74.5° C., mean 73.75° C. The temperature of gelatinization of *I. mrs. alan grey* is 1.6° C. less than that of

I. pallida queen of may and 1.2° C. less than that of *I. cengialti*. It is therefore closer to *I. cengialti* than to *I. pallida queen of may*.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 30 seconds. Complete gelatinization occurs in about 8 per cent of the entire number of grains and 14 per cent of the total starch in 5 minutes; in about 58 per cent of the grains and 72 per cent of the total starch in 15 minutes; in about 90 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 98 per cent of the grains and 99 per cent of the total starch in 45 minutes. (Chart D 421.)

Experiment repeated with practically precisely the same percentages.

The hilum becomes distinct, attended by the formation of a bubble in a smaller majority than in either parent. The lamellæ, as in *I. pallida queen of may*, are usually not visible. The grains become more refractive after the addition of the reagent, and the first part of the grain to show this change is a rather narrow band of starch at the margin which is as narrow and as refractive as in *I. pallida queen of may*. Gelatinization, as in both parents, begins at the corners of the distal margin, and in a large majority of the grains it progresses as in *I. pallida queen of may*, but in a small minority as in *I. cengialti*. In a very few grains it also begins at the proximal end immediately after it starts at the distal as in that starch. The gelatinized grains are as much swollen, have rather thick capsules, and are as distorted as in *I. pallida queen of may*. In this reaction *I. mrs. alan grey* shows qualitatively a somewhat closer relationship to *I. pallida queen of may* than to *I. cengialti*.

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in about 2 per cent of the grains and 6 per cent of the total starch in 5 minutes; in about 11 per cent of the grains and 57 per cent of the total starch in 15 minutes; in about 21 per cent of the grains and 86 per cent of the total starch in 30 minutes; in about 43 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 67 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 422.)

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 16 per cent of the total starch in 15 minutes; in about 12 per cent of the grains and 56 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 66 per cent of the total starch in 45 minutes; in about 20 per cent of the grains and 78 per cent of the total starch in 60 minutes. (Chart D 423.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 21 per cent of the grains and 63 per cent of the total starch in 15 minutes; in about 29 per cent of the grains and 71 per cent of the total starch in 30 minutes; in about 37 per cent of the grains and 80 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 83 per cent of the total starch in 60 minutes. (Chart D 424.)

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 64 per cent of the entire number of grains and 93 per cent of the total starch in 2 minutes; in about 85 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 425.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 10 per cent of the entire number of grains and 20 per cent of the total starch in 5 minutes; in about 14 per cent of the grains and 62 per cent of the total starch in 15 minutes; in about 31 per cent of the grains and 75 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 86 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 426.)

The hilum and lamellæ are as distinct as in *I. pallida queen of may*. Gelatinization begins at the hilum and progresses according to two methods. The first, which is seen in a great majority of the grains, is the same as that described for all the grains of *I. pallida queen of may*. The second, which is seen in a few grains, is the same as that described for a moderate minority of the grains of *I. cengialti*. The gelatinized grains are as much swollen, have as thin capsules, and are as much distorted as in *I. pallida queen of may*. In this reaction *I. mrs. alan grey* shows qualitatively a closer relationship to *I. pallida queen of may* than to *I. cengialti*.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 26 per cent of the entire number of grains and 66 per cent of the total starch in 5 minutes; in about 33 per cent of the grains and 73 per cent of the total starch in 15 minutes; in about 44 per cent of the grains and 81 per cent of the total starch in 30 minutes; in about 50 per cent of the grains and 88 per cent of the total starch in 45 minutes; in about 50 per cent of the grains and 90 per cent of the total starch in 60 minutes. (Chart D 427.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 37 per cent of the total starch in 5 minutes; in about 26 per cent of the grains and 53 per cent of the total starch in 15 minutes; in about 40 per cent of the grains and 77 per cent of the total starch in 30 minutes; in about 46 per cent of the grains and 81 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 83 per cent of the total starch in 60 minutes. (Chart D 428.)

The hilum and lamellæ are as distinct as in *I. pallida queen of may*. Gelatinization is preceded by granular formation in the portion of the grain comprehended between 2 pre-existing fissures as in both parents, and the granules are as fine and as regularly arranged as in *I. cengialti*. Gelatinization proceeds according to two methods which are the same as the two described under *I. pallida queen of may*, except that the second is seen in a somewhat larger proportion of grains than in that starch, but in a somewhat smaller proportion than in *I. cengialti*. The gelatinized grains are as much swollen and no more distorted than in *I. pallida queen of may*, but have as thick capsules as in *I. cengialti*. In this

reaction *I. mrs. alan grey* shows qualitatively a closer relationship to *I. pallida queen of may* than to *I. cengialti.*

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 28 per cent of the entire number of grains and 66 per cent of the total starch in 2 minutes; in about 31 per cent of the grains and 77 per cent of the total starch in 5 minutes; in about 47 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 66 per cent of the grains and 93 per cent of the total starch in 30 minutes. (Chart D 429.)

The reaction with *potassium sulphide* begins in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 6 per cent of the total starch in 30 minutes; little if any further advance occurs in 45 and 60 minutes, respectively. (Chart D 420.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 18 per cent of the entire number of grains and 45 per cent of the total starch in 2 minutes; in about 29 per cent of the grains and 64 per cent of the total starch in 5 minutes; in about 39 per cent of the grains and 75 per cent of the total starch in 15 minutes; in about 65 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 70 per cent of the grains and 93 per cent of the total starch in 45 minutes; in about 75 per cent of the grains and 94 per cent of the total starch in 60 minutes. (Chart D 431.)

The hilum and lamellæ are as distinct as in *I. pallida queen of may.* Gelatinization begins at the distal end and progresses as in *I. pallida queen of may,* with the exception of a few grains in which it begins at the hilum and progresses as in some of the grains of *I. cengialti.* The gelatinized grains are as much swollen, have as thick capsules, and are as much distorted as in *I. pallida queen of may.* In this reaction *I. mrs. alan grey* shows qualitatively a closer relationship to *I. pallida queen of may* than to *I. cengialti.*

The reaction with *sodium sulphide* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 20 per cent of the total starch in 15 minutes; in about 9 per cent of the grains and 31 per cent of the total starch in 30 minutes; in about 19 per cent of the grains and 40 per cent of the total starch in 45 minutes; in about 21 per cent of the grains and 52 per cent of the total starch in 60 minutes. (Chart D 432.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 88 per cent of the entire number of grains and 97 per cent of the total starch in 5 minutes; in more than 99 per cent of the grains and total starch in 10 minutes. (Chart D 433.)

The hilum becomes distinct, attended by the formation of a bubble in a smaller majority than in either parent. The lamellæ are usually invisible as in *I. pallida queen of may.* The grains become more refractive after the addition of the reagent, and the first portion of the grain to show this is a rather narrow band of starch at the margin, which is as narrow and as refractive as in *I. pallida queen of may.* Gelatinization begins at the distal end and progresses as in *I. pallida queen of may* in the great majority of the grains. In a rather small minority it progresses as in *I. cengialti.* It begins at the proximal end immediately following the distal in as many grains as in *I. cengialti.* The gelatinized grains are as much swollen, have rather thick capsules, and are as much distorted as in *I. pallida queen of may.* In this reaction *I. mrs. alan grey* shows qualitatively a somewhat closer relationship to *I. pallida queen of may* than to *I. cengialti.*

The reaction with *calcium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 11 per cent of the grains and 26 per cent of the total starch in 15 minutes; in about 13 per cent of the grains and 38 per cent of the total starch in 30 minutes; in about 18 per cent of the grains and 48 per cent of the total starch in 45 minutes; in about 20 per cent of the grains and 50 per cent of the total starch in 60 minutes. (Chart D 434.)

The reaction with *uranium nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 7 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 12 per cent of the total starch in 30 minutes; in about 6 per cent of the grains and 19 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 24 per cent of the total starch in 60 minutes. (Chart D 435.)

The reaction with *strontium nitrate* begins in a few grains immediately. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 8 per cent of the total starch in 5 minutes; in about 8 per cent of the entire number of grains and 23 per cent of the total starch in 15 minutes; in about 14 per cent of the grains and 43 per cent of the total starch in 30 minutes; in about 16 per cent of the grains and 50 per cent of the total starch in 45 minutes; in about 23 per cent of the grains and 55 per cent of the total starch in 60 minutes. (Chart D 436.)

Of all the species studied the margin of this species is the most resistant. This holds good with all or nearly all of the reagents.

The reaction with *cobalt nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and 0.5 per cent of the total starch in 15 minutes; in less than 0.5 per cent of the grains and 1 per cent of the total starch in 30 minutes; in less than 0.5 per cent of the grains and 2 per cent of the total starch in 45 minutes; in less than 0.5 per cent of the grains and 3 per cent of the total starch in 60 minutes. (Chart D 437.)

The reaction with *copper nitrate* begins in rare grains in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and

5 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 12 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 20 per cent of the total starch in 30 minutes; in about 5 per cent of the grains and 30 per cent of the total starch in 45 minutes; in about 6 per cent of the grains and 31 per cent of the total starch in 60 minutes. (Chart D 438.)

The reaction with *cupric chloride* begins in a few grains in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 7 per cent of the total starch in 15 minutes; in about 7 per cent of the entire number of grains and 42 per cent of the total starch in 30 minutes; in about 13 per cent of the grains and 44 per cent of the total starch in 45 minutes; in about 15 per cent of the grains and 48 per cent of the total starch in 60 minutes. (Chart D 439.)

The reaction with *barium chloride* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 0.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; slight advance in the grains and total starch in 30 minutes; in about 1 per cent of the grains and 4 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 5 per cent of the total starch in 60 minutes. (Chart D 440.)

The reaction with *mercuric chloride* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and 1 per cent of the total starch in 15 minutes; in less than 0.5 per cent of the grains and 2 per cent of the total starch in 30 minutes; in less than 0.5 per cent of the grains and 4 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 441.)

33. Starches of Iris persica var. purpurea, I. sindjarensis, and I. pursind.

Iris persica var. purpurea (Seed Parent).

(Plate 19, fig. 112; Charts D 442 to D 462.)

Histologic Properties.

In *form* the grains are usually simple and isolated. A few aggregates are noted and these are usually doublets or triplets composed of rather small grains of equal size. There is a moderate number of compound grains, usually consisting of 2 components, but sometimes of 3 and, rarely, of 8 or 9 components, and these are of three types. In the first, which is the most common, there are 2 or 3 components situated at or near the middle of the grain, each consisting of a hilum and 2 or 3 distinct lamellæ, and completely surrounded by 1 to 4 common secondary lamellæ, or joined only on opposite sides by 2 to 3 secondary lamellæ, and the whole surrounded by 1 or 2 secondary lamellæ. The second type consists of 2 to 8 or 9 components each represented only by a hilum, and these are surrounded by a homogeneous-looking mass outside of which are 1 to 4 or 5 lamellæ. The third type, which is of rare occurrence, consists of 2 components—a common sized or large grain to the side or distal end of which a small grain has become adherent, and the 2 are surrounded by 1 or 2 common secondary lamellæ. The grains are usually irregular in form and the irregularities are due to the following causes in the order of their frequency: (1) Protuberances of varying sizes and shapes, usually from the sides but also not infrequently from the ends (on some of the grains these protuberances may be so numerous as to give the grain a warty appearance); (2) slight, shallow depressions and elevations of the surface, giving an undulating or wavy outline to the margin; (3) a small set of secondary lamellæ whose longitudinal axis is usually at a right angle with that of the primary set; (4) very rarely, slight deviation of the longitudinal axis of the grain with a consequent bending of the grain near the distal end. The conspicuous forms are ovoid, pure and somewhat broadened, and nearly round. The additional forms are irregularly quadrilateral with rounded angles, irregularly triangular, dome-shaped, round, elongated elliptical with or without a flattened distal end, and lenticular. The grains are not flattened.

The *hilum*, when not fissured, is a moderately distinct, round, refractive spot. It is usually fissured, however, and the fissures are extensive, irregular, and branched, and have the following forms: (1) A single, crooked, transverse, oblique or longitudinal line which has many branches; (2) Y, T, or cruciform, all usually with many branches and placed in various axes of the grains; (3) a few irregularly stellate groups of fissures; (4) 2 fissures forming a figure like a pair of dividers. In the lenticular and elongated dome-shaped grains the hilum is elongated lenticular in form, and the whole hilum is occupied by a long, irregular, branching fissure, and in some of the compound grains there is a long branching fissure passing through all the hila of the components. The hilum is sometimes centric but commonly is eccentric from 0.44 to 0.27, usually 0.35, of the longitudinal axis.

The *lamellæ* are usually moderately distinct, sometimes very distinct, and sometimes not demonstrable. They are rather coarse and are continuous, and near the hilum they are round or lenticular in form, but near the margin they are somewhat irregular and the irregularities are in general like those of the outline of the grain. The number counted on the larger grains varies from 5 to 15, usually 8.

In *size* the grains vary from the smaller which are 2 by 2μ, to the larger elongated forms which are 50 by 30μ, and the larger broad forms which are 46 by 38μ, in length and breadth. The common size is 32 by 26μ.

Polariscopic Properties.

The *figure* is distinct, but in the great majority of the grains it is not well defined. The lines cross at a right angle or at an acute angle which varies considerably in size in the different grains. They are sometimes subdivided into 2, 3, or 4 divisions near the margin and are often somewhat bent.

The *degree of polarization* varies from moderately high to high (value 70). There is often some variation in a given aspect of an individual grain.

With *selenite* the quadrants are usually not clear-cut. They are unequal in size and usually somewhat irregular in shape. The colors are usually pure, but there are some grains which have a greenish tinge.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate blue-violet (value 55), and the color deepens rapidly until they are deeply colored and have assumed more of a bluish tint. With 0.125 per cent Lugol's solution the grains all color a light blue-violet, and the color deepens rapidly until all the grains are deeply colored. After heating in water until all the grains are completely gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* are all moderately colored and the *solution* very deeply colored. If the preparation is boiled for 2 minutes and then treated with a 2 per cent Lugol's solution, most of the *grain-residues* are not colored, except the capsules, but a moderate number are colored a light or a very light indigo; the *capsules* are all colored violet or reddish violet; and the *solution* a very deep indigo.

Aniline Reactions.

With *gentian violet* the grains color very lightly to lightly at once, and in 30 minutes they are moderately stained (value 45). There are a few grains which are less colored than the others but most of the grains are moderately stained.

With *safranin,* the grains stain very lightly at once, and in 30 minutes they are moderately colored (value 50) more than with gentian violet, and practically all the grains are moderately stained.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 64° to 66° C., and of all is 68° to 70° C., mean 69° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 1 minute. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 12 per cent of the total starch in 5 minutes; in about 16 per cent of the grains and 20 per cent of the total starch in 15 minutes; in about 27 per cent of the grains and 30 per cent of the total starch in 30 minutes; in about 28 per cent of the grains and 36 per cent of the total starch in 45 minutes; in about 30 per cent of the grains and 36 per cent of the total starch in 60 minutes. (Chart D 442.)

The hilum is very distinct and a bubble is usually formed there. The lamellæ are at first indistinct, but later become distinct, especially in the larger grains. The grains become more refractive in appearance after the reaction begins, and the first part to show this is the marginal starch, which forms a narrow and refractive band around the entire grain. Gelatinization begins at small cracks or indentations in the distal margin and the majority of the grains are invaded for some distance through these cracks before the marginal portion between them is gelatinized, so that small, cup-shaped depressions are formed in the grain, making the progress of gelatinization somewhat uneven. In this manner, preceded by an increased refractivity but no pitting or granulation of the grain, gelatinization progresses from the distal margin toward the hilum. When the hilum is reached the bubble, usually present there, enlarges, then shrinks and disappears, and as the starch at the proximal end becomes more refractive and somewhat swollen when the hilum enlarges, it also is quickly gelatinized, leaving a small circular portion of the grain just distal to the hilum ungelatinized, and this also is finally gelatinized. In some of the grains, after the initial cracking of the margin and gelatinization at those points, the process extends along the margin between these points until about half of the entire margin of the grain is gelatinized and then proceeds smoothly toward the proximal end. The rest of the reaction is the same as already described. The gelatinized grains are large and considerably distorted, especially at the distal end. They do not retain much resemblance to the form of the untreated grain.

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 11 per cent of the total starch in 5 minutes; in about 23 per cent of the grains and 83 per cent of the total starch in 15 minutes; in about 34 per cent of the grains and 91 per cent of the total starch in 30 minutes; in about 51 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 74 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 443.)

The reaction with *pyrogallic acid* begins in 30 seconds. Complete gelatinization occurs in about 16 per cent of the entire number of grains and 66 per cent of the total starch in 5 minutes; in about 74 per cent of the grains and 98 per cent of the total starch in 15 minutes; in about 90 per cent of the grains and 99 per cent of the total starch in 30 minutes. (Chart D 444.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 39 per cent of the entire number of grains and 78 per cent of the total starch in 5 minutes; in about 61 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 82 per cent of the grains and 98 per cent of the total starch in 30 minutes; very little if any further advance in 45 and 60 minutes, respectively. (Chart D 445.) The margin of a small percentage of the grains is quite resistant.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 77 per cent of the entire number of grains and 86 per cent of the total starch in 2 minutes; in about 95 per cent of the total starch in 3 minutes; in about 98 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 446.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 82 per cent of the entire number of grains and 95 per cent of the total starch in 5 minutes; in about 96 per cent of the total starch in 10 minutes; in about 97 per cent of the grains and 99 per cent of the total starch in 15 minutes. (Chart D 447.)

The hilum is very distinct, and a large bubble is moderately often observed to form there, which may vary somewhat in position and first increase slowly in size during the reaction, and later shrink and finally disappear. The lamellæ are distinct until late in the reaction. Gelatinization begins at the hilum which enlarges rapidly. From this point there are two types of procedure to be noted. In the first, which occurs in the great majority of the grains, as the hilum enlarges and the grain swells, moderately fine striæ appear, radiating in all directions from the hilum to the margin, and

dividing the grain into rows of rather fine granules, arranged in the manner of the lamellæ. As enlargement of both hilum and grain continues, the less resistant starch is gelatinized and the more resistant portion forms a lamellated granular band at the margin, which remains lamellated and granular until very late in the reaction, becoming thinner and more nearly transparent, more quickly at the distal end (or what may be considered the distal end) than at the proximal end and sides, until finally only the thin capsule remains. In some of these grains, the starch around the hilum, at the beginning of the reaction, is divided into rather coarse granules which are very resistant, and which as the reaction progresses are pushed to the inner border of the marginal band before described, and remains there, becoming gradually smaller and more refractive long after the rest of the material of the grain has been gelatinized, until, finally, they too are gelatinized. In the second type of procedure, which occurs in a rather small number of grains, which are somewhat elongated in form, 2 refractive fissures, which are often already present in the untreated grain, run from the hilum to the distal margin, branching out as they near the margin. The starch comprehended between them becomes more refractive and is divided into granules, and this portion of the grain is more rapidly gelatinized than the material at the proximal end and sides, which forms a densely striated, lamellated, marginal band, and this gradually becomes thinner and more nearly transparent until only the thin capsule is left.

The gelatinized grains are usually considerably swollen, rather thin walled, and not much distorted especially at the proximal end. There is not much dissolution of the capsule except after complete gelatinization has occurred.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 44 per cent of the entire number of grains and 80 per cent of the total starch in 5 minutes; in about 68 per cent of the grains and 98 per cent of the total starch in 15 minutes; in about 72 per cent of the grains and 99 per cent of the total starch in 30 minutes. (Chart D 448.) A delicate, complete, or partial layer of starch at the margin of a small percentage of the grains is quite resistant.

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 77 per cent of the grains and 95 per cent of the total starch in 5 minutes; in 96 per cent of the total starch in 10 minutes; in about 93 per cent of the grains and 99 per cent of the total starch in 15 minutes. (Chart D 449.)

The hilum is very distinct, and a large bubble is often formed there. The lamellæ are not distinct, and sometimes can not be distinguished. Gelatinization begins at the hilum, which in the great majority of the grains enlarges somewhat, and rather coarse striæ appear which radiate from the hilum throughout the grain to the margin. If fissures are present in the untreated grain, these enlarge and extend further into the substance of the grain. The bubble, which was large, shrinks and disappears, and the hilum and the whole grain begin to enlarge steadily and with moderate rapidity. The more resistant starch is pushed to the margin where it forms a striated band which soon becomes granular and, as the reaction proceeds, this granular band gradually becomes thinner and more nearly transparent, and more homogeneous in appearance, until finally only the thin capsule is left. In some of the elongated grains in which 2 refractive fissures proceeding from the hilum exist in the untreated grain, the fissures become more extensive, and branching toward the distal end, and the part of the grain included between them and the hilum and the distal margin becomes more refractive in appearance and then is divided into many granules. The proximal end is, however, nearly always the first to be gelatinized, and there is always a striated, lamellated band around the entire margin, and, after the rest of the grain is completely gelatinized, there is often a collection of rather coarse, refractive granules at the distal margin which are very resistant and remain for some time ungelatinized.

The gelatinized grains are much swollen, and have rather thick capsules, but are much distorted and do not retain much resemblance to the form of the untreated grain.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 77 per cent of the entire number of grains and 98 per cent of the total starch in 2 minutes; in about 90 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 450.)

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 11 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 14 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 20 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 21 per cent of the total starch in 45 and 60 minutes. (Chart D 451.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 66 per cent of the entire number of grains and 92 per cent of the total starch in 2 minutes; in about 95 per cent of the total starch in 3 minutes; and in about 92 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 452.)

The hilum becomes very distinct, and a bubble is apparently never formed there. In a few grains, 2 refractive fissures, which extend from the hilum nearly to the distal margin, and are present before the addition of the reagent, become more prominent, more extensive, and more branched. The lamellæ are very distinct and remain so during the greater part of the reaction. Gelatinization begins at the hilum, and in the majority of the grains a few striæ appear which radiate from the hilum in all directions throughout the grain to the margin. The hilum enlarges equally in all directions, and the whole grain slowly swells, the more resistant starch forming a striated, lamellated band around the margin. Later this band is divided into rows of granules which retain the lamellated appearance for a long time. As reaction proceeds the granules become progressively thinner and more nearly transparent until they disappear and only the thin capsule is left. In some grains in addition to this formation of granules at the margin, irregular and refractive granules are formed of the portion immediately surrounding the hilum, and these, as swelling proceeds, are scattered rather irregularly through the grain and prove to be the most resistant

part. In a small minority of the grains, in which the 2 refractive fissures already described are observed, the hilum enlarges somewhat and the 2 fissures enlarge, and, as they extend more nearly to the distal margin, branch out considerably. The part of the grain included between them and the hilum and the distal margin becomes more refractive in appearance and is divided into fine granules which are placed in rows, retaining the lamellar arrangement. Gelatinization occurs first in this part of the grain and proceeds from the hilum towards the distal margin. The more resistant starch at the proximal end and sides nearby forms a lamellated, striated band at the margin, which grows progressively thinner and more nearly transparent, losing at the same time the striated appearance, but retaining the lamellar arrangement until the starch is nearly all gelatinized.

The gelatinized grains are swollen, have rather thick capsules, and are slightly to considerably distorted, but they usually retain some resemblance to the form of the untreated grain.

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 27 per cent of the entire number of grains and 67 per cent of the total starch in 5 minutes; in about 67 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 87 per cent of the grains and 98 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes, respectively. (Chart D 453.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 19 per cent of the entire number of grains and 27 per cent of the total starch in 5 minutes; in about 31 per cent of the grains and 50 per cent of the total starch in 10 minutes; in about 67 per cent of the grains and 75 per cent of the total starch in 15 minutes; in about 98 per cent of the grains and 99 per cent of the total starch in 30 minutes. (Chart D 454.)

The hilum is distinct, and a small bubble is often formed there. The lamellæ gradually become moderately distinct, and remain so until obliterated by gelatinization. The grains become more refractive in appearance, after the reagent is added, and the first part of the grain to show this is the margin, about which a rather narrow, refractive band is formed. Gelatinization begins at the distal margin at a number of discrete points, which are first invaded by short, wide cracks extending inward only to the limits of the refractive marginal band already mentioned. The starch on either side of these cracks is then gelatinized, and rounded hollows are formed, which persist for some time. In the meantime the marginal material between these points is gelatinized, and gelatinization proceeds toward the hilum and proximal end. Gelatinization proceeds smoothly, the hollows first formed being obliterated in most of the grains, and the reaction is often preceded by the invasion of the ungelatinized grain by indistinct, faintly refractive fissures. Just before the hilum is reached, the bubble suddenly enlarges, and then is seen to extend down a canal which is formed in the interior of the grain from the hilum to the gelatanized portion, and then to shrink and disappear, and the hilum enlarges rapidly, leaving only the proximal portion ungelatinized This starch may gelatinize rapidly or somewhat slowly, and its gelatinization is accompanied by a considerable invagination of the capsule at this point. The gelatinized grains are considerably swollen, have rather thin capsules, and are very much distorted, retaining little or none of the form of the untreated grain.

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 7 per cent of the entire number of grains and 32 per cent of the total starch in 5 minutes; in about 45 per cent of the grains and 82 per cent of the total starch in 15 minutes; in about 61 per cent of the grains and 89 per cent of the total starch in 30 minutes; in about 71 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 85 per cent of the grains and 96 per cent of the total starch in 60 minutes. (Chart D 455.)

The reaction with *uranium nitrate* begins immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 16 per cent of the total starch in 5 minutes; in about 23 per cent of the grains and 66 per cent of the total starch in 15 minutes; in about 43 per cent of the grains and 84 per cent of the total starch in 30 minutes; in about 60 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 73 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 456.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 9 per cent of the entire number of grains and 24 per cent of the total starch in 5 minutes; in about 66 per cent of the grains and 89 per cent of the total starch in 15 minutes; in about 86 per cent of the grains and 98 per cent of the total starch in 30 minutes. (Chart D 457.)

The reaction with *cobalt nitrate* begins in 30 seconds. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 7 per cent of the grains and 25 per cent of the total starch in 15 minutes; in about 8 per cent of the grains and 36 per cent of the total starch in 30 minutes; in about 14 per cent of the grains and 43 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 44 per cent of the total starch in 60 minutes. (Chart D 458.)

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 9 per cent of the entire number of grains and 54 per cent of the total starch in 5 minutes; in about 52 per cent of the grains and 82 per cent of the total starch in 15 minutes; in about 73 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 78 per cent of the grains and 97 per cent of the total starch in 45 minutes; in about 82 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 459.)

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 11 per cent of the entire number of grains and 38 per cent of the total starch in 5 minutes; in about 58 per cent of the grains and 80 per cent of the total starch in 15 minutes; in about 79 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 90 per cent of the grains and 98 per cent of the total starch in 45 minutes. (Chart D 460.)

The reaction with *barium chloride* begins immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 8 per cent of

the total starch in 5 minutes; in about 9 per cent of the grains and 16 per cent of the total starch in 15 minutes; in about 10 per cent of the grains and 32 per cent of the total starch in 30 minutes; in about 11 per cent of the grains and 43 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 47 per cent of the total starch in 60 minutes. (Chart D 461.)

The reaction with *mercuric chloride* begins immediately. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 23 per cent of the total starch in 5 minutes; in about 45 per cent of the grains and 77 per cent of the total starch in 15 minutes; in about 63 per cent of the grains and 87 per cent of the total starch in 30 minutes; in about 71 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 75 per cent of the grains and 96 per cent of the total starch in 60 minutes. (Chart D 462.)

Iris sindjarensis (Pollen Parent).

(Plate 19, fig. 113; Charts D 442 to D 462.)

Histologic Properties.

In *form* a small majority of the grains are simple and usually isolated. Only a few aggregates in the form of small doublets of equal-sized grains are noted. There are many more compound grains than in *I. persica* var. *purpurea,* which usually consist of 2 to 3, but sometimes of 8 or 9, components, and all belonging to one or another of three types. The first type, which is the most common, consists of 2 or more components each represented by a hilum and 1 lamella, arranged linearly or irregularly in a homogeneous-looking space and surrounded by 4 to 6 or 7 common secondary lamellæ. The second type consists of 2 to 3 components linearly arranged, each consisting of a hilum and 2 or 3 lamellæ and all surrounded by 2 to 4 common secondary lamellæ, a type which is not nearly so common as in *I. persica* var. *purpurea.* The third type, which is more numerous than in *I. persica* var. *purpurea,* consists of a large, simple or compound grain, to the side or end of which one or more small, simple or compound grains have become attached, and the whole surrounded by 1 or 2 common lamellæ. The grains are usually moderately regular in form, much more regular than in *I. persica* var. *purpurea,* and any irregularities which occur are due to the following causes in the order of frequency of occurrence: (1) To small, pointed or rounded protuberances usually from the sides, but sometimes from the distal or proximal ends; (2) a secondary set of lamellæ whose longitudinal axis is usually at a right angle with that of the primary set; (3) to very few and very shallow depressions and elevations of the surface of a grain producing an undulating or wavy outline of the margin; (4) rarely, a small, shallow notch on the middle of the distal margin. The conspicuous forms of the simple grains are ovoid and elliptical, both often with a flattened distal end; and of the compound grains, nearly round, ovoid, and elliptical with both ends rounded. The additional forms of the simple grains are lenticular, round and nearly round, dome-shaped and irregularly quadrilateral with rounded angles; and of the compound grains, irregularly quadrilateral with rounded angles, dome-shaped, and triangular. The grains are not flattened.

The *hilum,* when not fissured, is more distinct than in *I. persica* var. *purpurea,* and is a round or lenticular, refractive spot. It is, however, usually fissured, but not so often, nor so irregularly, nor so extensively as in *I. persica* var. *purpurea.* The fissures have the following forms: (1) 2 lines somewhat branched, forming an angle like a pair of dividers, crossing which lines near the angle there may be a single, straight, horizontal line; (2) Y-shaped; (3) an irregularly stellate arrangement of many fissures; (4) rarely, a single, straight, transverse or oblique line. In the compound grains the hila are sometimes separated from one another by fissures which do not extend to the margin, but in no case was a single fissure noted, as in *I. persica* var. *purpurea,* which passes through all the hila. The hilum is sometimes centric but is commonly eccentric from 0.44 to 0.27, usually 0.31, of the longitudinal axis. The hilum is usually 0.04 more eccentric than that of *I. persica* var. *purpurea.*

The *lamellæ* are as distinct as in *I. persica* var. *purpurea,* but are not so coarse and are more regular in outline. Near the hilum they are round, and rarely elliptical, in outline, and near the margin they follow the form of the contour of the grain. The number counted on the larger grains varies from 6 to 15, usually 12, larger than in *I. persica* var. *purpurea.*

In *size* the grains vary from the smaller which are 2 by 2μ, to the larger elongated forms which are 42 by 24μ, and the larger broader forms which are 42 by 34μ, in length and breadth. The common sizes are 26 by 18μ and 26 by 24μ. The common sizes of *I. sandjarensis* are 6μ shorter and 8μ narrower and 6μ shorter and 2μ narrower, and, on the whole, smaller than that of *I. persica* var. *purpurea.*

Polariscopic Properties.

The *figure* is as distinct as in *I. persica* var. *purpurea* and much better defined than in that starch. The lines cross more often at a right angle and where they do not there is less variation in the size of the acute angles than in *I. persica* var. *purpurea.* They are not so often bent nor so often divided into 2, 3, or 4 divisions as in that starch.

The *degree of polarization* varies from moderately high to very high (value 75), 5 units higher than in *I. persica* var. *purpurea.* There is also less variation in the same aspect of a given grain as in that starch.

With *selenite* the quadrants are much more clear-cut. They are not so unequal in size nor so irregular in shape as in *I. persica* var. *purpurea.* The colors are usually pure, but there are more grains which have a greenish tinge than in that starch.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate blue-violet (value 50), 5 units less than in *I. persica* var. *purpurea.* The color deepens rapidly until it is very deep and at the same time has assumed more of a bluish tint. With 0.125 per cent Lugol's solution the grains all color a light blue-violet, less than in *I. persica* var. *purpurea,* and the color deepens with moderate rapidity until it is very deep and at the same time has assumed more of a bluish tint. After heating in water until all the grains are completely gelatinized, then treating with 2 per cent Lugol's solution, the gelatinized *grains* are colored a light or a light to moderate indigo, less than in *I. persica* var. *purpurea;* and the *solution* a very deep indigo, more than in *I. persica* var.

purpurea. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, most of the *grain-residues* are not colored except the capsules, and many less grain-residues than in *I. persica* var. *purpurea* are colored a light indigo; the *capsules* are all colored a reddish violet, less than in *I. persica* var. *purpurea;* and the *solution* a very deep indigo as in *I. persica* var. *purpurea*.

Aniline Reactions.

With *gentian violet* the grains usually stain very lightly at once, less than in *I. persica* var. *purpurea,* and in 30 minutes they are moderately colored (value 42), 3 units less than in *I. persica* var. *purpurea.* There is a greater proportion of the grains light to moderately stained than in *I. persica* var. *purpurea.*

With *safranin* the grains as in *I. persica* var. *purpurea* stain very lightly at once, and in 30 minutes they are moderately colored (value 47), 3 units less than in *I. persica* var. *purpurea.*

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 63.5° to 65° C., and of all 66° to 67° C., mean 66.5° C. This is 2.5° C. less than that of *I. persica* var. *purpurea.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 1 minute. Complete gelatinization occurs in about 8 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 9 per cent of the grains and 12 per cent of the total starch in 15 minutes; in about 20 per cent of the grains and 24 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 25 per cent of the total starch in 45 minutes; in about 27 per cent of the grains and 30 per cent of the total starch in 60 minutes. (Chart D 442.)

The hilum is as distinct as in *I. persica* var. *purpurea,* and a bubble is often formed there, but not so often as in *I. persica* var. *purpurea.* The lamellæ, at first, are not distinct, but later become more distinct than in *I. persica* var. *purpurea.* The grains, as in *I. persica* var. *purpurea,* become more refractive in appearance as the reaction progresses, and the first portion to show this is the marginal starch which forms a narrow, refractive band around the entire grain. Gelatinization begins at the margin as in *I. persica* var. *purpurea,* but usually only at two points, and there are no cracks or fissures as noted in that starch. In some of the elongated forms 2 longitudinal fissures extend toward the hila from the distal margin; in the majority, however, the marginal portion between the two points already mentioned is gelatinized, and then gelatinization proceeds smoothly toward the proximal end, and the surface being less resistant than the interior is gelatinized first, producing a cone-shape on the distal end of the ungelatinized starch. When the hilum is reached, the bubble if present swells, shrinks, and then disappears, and the rest of the reaction is the same as already described under *I. persica* var. *purpurea.* The gelatinized grains are large, thicker walled, and not so much distorted as in *I. persica* var. *purpurea,* and they retain more resemblance to the form of the untreated grain.

The reaction with *chromic acid* begins in 30 seconds. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 25 per cent of the total starch in 5 minutes; in about 37 per cent of the grains and 85 per cent of the total starch in 15 minutes; in about 40 per cent of the grains and 92 per cent of the total starch in 30 minutes; in about 57 per cent of the grains and 97 per cent of the total starch in 45 minutes; in about 80 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 443.)

The reaction with *pyrogallic acid* begins in 30 seconds. Complete gelatinization occurs in about 25 per cent of the entire number of grains and 71 per cent of the total starch in 5 minutes; in about 88 per cent of the grains and 98 per cent of the total starch in 15 minutes; in about 94 per cent of the grains and 99 per cent of the total starch in 30 minutes. (Chart D 444.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 53 per cent of the entire number of grains and 90 per cent of the total starch in 5 minutes; in about 65 per cent of the grains and 98 per cent of the total starch in 15 minutes; in about 85 per cent of the grains and 99 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes, respectively. (Chart D 445.) The margin of a small percentage of grains is quite resistant as in *I. persica* var. *purpurea.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 91 per cent of the entire number of grains and 97 per cent of the total starch in 2 minutes; in more than 99 per cent of the grains and total starch in 5 minutes. (Chart D 446.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 87 per cent of the entire number of grains and 98 per cent of the total starch in 5 minutes; in more than 99 per cent of the grains and total starch in 15 minutes. (Chart D 447.)

The hilum is as distinct as in *I. persica* var. *purpurea,* and there is not so frequently a bubble as in the starch. The lamellæ are distinct, but not quite so distinct as in *I. persica* var. *purpurea.* Gelatinization, as in *I. persica* var. *purpurea,* begins at the hilum and the two methods of procedure noted in that starch are also seen here. In the first, the striæ are very much finer and less prominent, but the lamellæ remain visible much longer and 2 or 3 may be seen in the nearly transparent marginal band long after gelatinization is otherwise apparently complete. In the second type the refractive fissures are not so refractive, so prominent, or so branched as in *I. persica* var. *purpurea,* and the distal material is often invaded by several fissures from the margin which apparently make it less resistant as gelatinization starts at the hilum and then quickly at the distal margin, and the two reactions meet approximately midway between the hilum and the distal margin.

The gelatinized grains are much swollen, have thinner capsules, and are somewhat more distorted than in *I. persica* var. *purpurea,* and do not retain as much resemblance to the form of the untreated grain as *I. persica* var. *purpurea.*

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 62 per cent of the entire number of grains and 85 per cent of the total starch in 5 minutes; in about 80 per cent of

the grains and 98 per cent of the total starch in 15 minutes; in about 84 per cent of the grains and 99 per cent of the total starch in 30 minutes; little if any further advance occurs in 45 and 60 minutes, respectively. (Chart D 448.) The margin of a smaller percentage of grains is resistant than in *I. persica* var. *purpurea*, but a proportionately larger number of entire grains are resistant at 5 minutes than in *I. persica* var. *purpurea*; hence, the difference between the complete and total percentage of gelatinization is not so great as in *I. persica* var. *purpurea*.

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 85 per cent of the entire number of grains and 98 per cent of the total starch in 5 minutes; in about 94 per cent of the grains and in more than 99 per cent of the total starch in 15 minutes. (Chart D 449.)

The hilum is as distinct as in *I. persica* var. *purpurea*, but a bubble is not so often formed there. The lamellæ are somewhat more distinct than in *I. persica* var. *purpurea*. Gelatinization begins at the hilum which enlarges somewhat, and in some grains fine striæ may be seen to radiate from the hilum throughout the grain to the margin. This striation is not nearly so marked as in *I. persica* var. *purpurea*. The hilum continues to enlarge and also the grain, and the more resistant starch is pushed to the margin, where it forms a lamellated and usually a non-striated band, differing from *I. persica* var. *purpurea* in which grains the marginal band was striated but not often lamellated. In the elongated grains, the reaction is very close to that described under *I. persica* var. *purpurea*, except that there are not so many nor such refractive granules formed and these granules are not so resistant as in *I. persica* var. *purpurea*. The gelatinized grains are somewhat swollen, and have thicker walls, and are not so much distorted as in *I. persica* var. *purpurea*, and retain much more of the form of the untreated grain.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 87 per cent of the entire number of grains and in more than 99 per cent of the total starch in 2 minutes; in about 95 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 450.)

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 22 per cent of the total starch in 5 minutes; in about 7 per cent of the grains and 33 per cent of the total starch in 15 minutes; in about 11 per cent of the grains and 37 per cent of the total starch in 30 minutes; in about 14 per cent of the grains and 40 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 451.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 77 per cent of the entire number of grains and 95 per cent of the total starch in 2 minutes; in more than 99 per cent of the grains and total starch in 5 minutes. (Chart D 452.)

The hilum and lamellæ are more distinct than in *I. persica* var. *purpurea*, and 2 refractive fissures extending from the hilum towards the distal margin appear in very few grains, many less than in *I. persica* var. *purpurea*. Gelatinization begins at the hilum as in *I. persica* var. *purpurea*, and the processes of gelatinization in the two types of grains present are very similar to those described under *I. persica* var. *purpurea*. The main differences noted are that in these grains the starch immediately around the hilum is more irregularly and extensively fissured than in *I. persica* var. *purpurea*, so that there is a greater persistence of resistant granules in the gelatinized grains; that the striæ with which the majority of the grains are covered are coarser and more distinct; that the granules which are formed at the margin are coarser; and that the lamellated appearance of this marginal band persists for an even longer time. The gelatinized grains are more swollen, and the capsules are thinner but less distorted, than in *I. persica* var. *purpurea*.

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 54 per cent of the entire number of grains and 79 per cent of the total starch in 5 minutes; in about 83 per cent of the grains and 96 per cent of the total starch in 15 minutes; in about 92 per cent of the grains and 98 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes, respectively. (Chart D 453.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 10 per cent of the entire number of grains and 16 per cent of the total starch in 5 minutes; in about 37 per cent of the grains and 47 per cent of the total starch in 10 minutes; in about 60 per cent of the grains and 70 per cent of the total starch in 15 minutes; in about 98 per cent of the grains and 99 per cent of the total starch in 30 minutes. (Chart D 454.)

This was repeated because it is usually more rapid than *I. persica* var. *purpurea*, but the results were about the same as the above.

The hilum is more distinct than in *I. persica* var. *purpurea*, but a bubble is not so often formed there, and when it appears it is very small. The lamellæ are more distinct than in *I. persica* var. *purpurea*. The grains become more refractive in appearance after the addition of the reagent, and the first part to show this is the margin around which is formed a rather narrow refractive band which is more refractive than in *I. persica* var. *purpurea*. Gelatinization begins at the distal margin, but usually not at separate points which have become cracked first, as in *I. persica* var. *purpurea*, but all along the border. In more grains than in *I. persica* var. *purpurea*, 2 longitudinal refractive fissures extend upward from the distal margin toward the hilum, and the starch included between them is gelatinized somewhat more rapidly than the marginal portion, otherwise the progress of gelatinization is much smoother and is unaccompanied by any of the longitudinal fissuring noted in *I. persica* var. *purpurea*. A canal is not seen to form from the hilum to the gelatinized portion of the grain as in *I. persica* var. *purpurea*, and the bubble swells somewhat but quickly disappears. The gelatinized grains are much swollen and have thicker capsules, but are usually as much distorted as in *I. persica* var. *purpurea*.

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 9 per cent

of the entire number of grains and 46 per cent of the total starch in 5 minutes; in about 54 per cent of the grains and 86 per cent of the total starch in 15 minutes; in about 74 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 83 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 88 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 455.)

The reaction with *uranium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 47 per cent of the total starch in 5 minutes; in about 60 per cent of the grains and 86 per cent of the total starch in 15 minutes; in about 71 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 83 per cent of the grains and 97 per cent of the total starch in 45 minutes; in about 86 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 456.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 10 per cent of the entire number of grains and 45 per cent of the total starch in 5 minutes; in about 74 per cent of the grains and 92 per cent of the total starch in 15 minutes; in about 95 per cent of the grains and 98 per cent of the total starch in 30 minutes. (Chart D 457.)

The reaction with *cobalt nitrate* begins in 30 seconds. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 12 per cent of the total starch in 5 minutes; in about 15 per cent of the grains and 40 per cent of the total starch in 15 minutes; in about 20 per cent of the grains and 50 per cent of the total starch in 30 minutes; slight advance in 45 minutes; in about 24 per cent of the grains and 51 per cent of the total starch in 60 minutes. (Chart D 458.)

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 26 per cent of the entire number of grains and 58 per cent of the total starch in 5 minutes; in about 60 per cent of the grains and 86 per cent of the total starch in 15 minutes; in about 78 per cent of the grains and 96 per cent of the total starch in 30 minutes; in about 82 per cent of the grains and 96 per cent of the total starch in 45 minutes; in about 89 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 459.)

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 24 per cent of the entire number of grains and 64 per cent of the total starch in 5 minutes; in about 64 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 80 per cent of the grains and 98 per cent of the total starch in 30 minutes; in about 92 per cent of the grains and in more than 99 per cent of the total starch in 45 minutes. (Chart D 460.)

The reaction with *barium chloride* begins immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 37 per cent of the total starch in 15 minutes; in about 13 per cent of the grains and 51 per cent of the total starch in 30 minutes; in about 27 per cent of the grains and 58 per cent of the total starch in 45 minutes; in about 34 per cent of the grains and 68 per cent of the total starch in 60 minutes. (Chart D 461.)

The reaction with *mercuric chloride* begins immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 34 per cent of the total starch in 5 minutes; in about 50 per cent of the grains and 80 per cent of the total starch in 15 minutes; in about 75 per cent of the grains and 88 per cent of the total starch in 30 minutes; in about 83 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 88 per cent of the grains and 96 per cent of the total starch in 60 minutes. (Chart D 462.)

A larger percentage of grains becomes completely gelatinized than in *I. persica* var. *purpurea*, but there are more scattered entire grains which resist the reaction for a longer period, hence the variation between the percentage.

Iris pursind (Hybrid).

(Plate 19, fig. 114; Charts D 442 to 462.)

Histologic Properties.

In *form* the grains are usually simple and isolated. There are a few aggregates as in the parents, and even fewer compound grains than in *I. persica* var. *purpurea*, and all are of the same types as those described under *I. persica* var. *purpurea*. The grains are not so irregular as in *I. persica* var. *purpurea* and are slightly more irregular than in *I. sindjarensis*, and the irregularities are due to the following causes: (1) Pointed and rounded protuberances of various sizes; (2) small, shallow depressions and elevations on the surface, giving an undulating outline to the margin; (3) a notch in the middle of the distal margin; (4) rarely, deviation of the longitudinal axis. The conspicuous forms are both slender and broad ovoid, and lenticular. The additional forms are nearly round, elliptical, irregularly quadrilateral, dome-shaped, and triangular. The grains are not flattened. In form this starch shows a closer relationship to *I. persica* var. *purpurea* than to *I. sindjarensis*.

The *hilum* when not fissured is as distinct as in *I. persica* var. *purpurea*, and it is usually fissured, even more often and more extensively than in *I. persica* var. *purpurea* and the types of fissuring are the same as in *I. persica* var. *purpurea*. The hilum is sometimes centric as in the parents, but is commonly eccentric from 0.44 to 0.26, usually 0.32, of the longitudinal axis. The hilum is 0.01 more eccentric than that of *I. sindjarensis*, and 0.03 more eccentric than that of *I. persica* var. *purpurea*. In the character of the hilum *I. pursind* is closer to *I. persica* var. *purpurea* than to *I. sindjarensis*, but in the degree of eccentricity it is closer to *I. sindjarensis* than to *I. persica* var. *purpurea*.

The *lamellæ* are not as distinct as in either parent, and can not be demonstrated in many grains. When visible, they appear as continuous, rather coarse rings which are circular near the hilum, and have the form of the outline of the grain near the margin. The number counted on the larger grains varies from 5 to 12, usually 8.

In the character and the number of the lamellæ *I. pursind* shows a closer relationship to *I. persica* var. *purpurea* than to *I. sindjarensis*.

In *size* the grains vary from the smaller which are 2 by 2μ, to the larger elongated forms which are 40 by 24μ, and the larger broad forms which are 42 by 34μ,

in length and breadth. The common sizes are 26 by 22μ and 30 by 24μ. *I. pursind* is somewhat closer in size to *I. sindjarensis* than to *I. persica* var. *purpurea.* The common sizes are in one case as long and 4μ broader, and in the other 4μ longer and the same breadth, as the common sizes of *I. sindjarensis;* and are, respectively, 6μ shorter and 4μ narrower, and 2μ shorter and 2μ narrower, than the common sizes of *I. persica* var. *purpurea.*

Polariscopic Properties.

The *figure* is as distinct and nearly as well defined as in *I. sindjarensis,* and much better defined than in *I. persica* var. *purpurea.* The lines, as in *I. persica* var. *purpurea,* cross at a right angle or at an acute angle which varies considerably in different grains. They are as often bent as in *I. persica* var. *purpurea,* but somewhat less often bisected or subdivided into 3 or 4 divisions.

The *degree of polarization* varies from moderate to high (value 65), 5 units lower than *I. persica* var. *purpurea* and 10 units lower than *I. sindjarensis.* There is some variation in a given aspect of an individual grain as in *I. persica* var. *purpurea.*

With *selenite* the quadrants are nearly as clear-cut as in *I. sindjarensis,* and more so than in *I. persica* var. *purpurea.* The quadrants as in *I. persica* var. *purpurea* are unequal in size and irregular in shape. The colors are not so pure as in either parent, but are closer to those of the grains of *I. persica* var. *purpurea* than of the grains of *I. sindjarensis.*

In the character of the figure, the degree of polarization, and the appearances with selenite, *I. pursind* shows a closer relationship to *I. persica* var. *purpurea* than to *I. sindjarensis.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate blue-violet (value 50), the same as in *I. sindjarensis* and 5 units lower than in *I. persica* var. *purpurea.* With 0.125 per cent Lugol's solution the grains are colored a light blue-violet, the same as in *I. sindjarensis* and less than in *I. persica* var. *purpurea.* After heating in water until all the grains are completely gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* are colored a light or a light to moderate indigo, and the *solution* a very deep indigo, as in *I. sindjarensis.* If the preparation is boiled for 2 minutes and then treated with a 2 per cent Lugol's solution most of the *grain-residues* are not colored except the capsule, and the *capsules* are colored a reddish violet, and the *solution* a very deep indigo, as in *I. sindjarensis.* Qualitatively and quantitatively the reactions with iodine show a closer relationship to *I. sindjarensis* than to *I. persica* var. *purpurea.*

Aniline Reactions.

With *gentian violet* the grains, as in *I. sindjarensis,* stain very lightly at once, and in 30 minutes they are light to moderately colored (value 40), 5 units less than in *I. persica* var. *purpurea,* and 2 units less than in *I. sindjarensis.* There is a much greater proportion of grains light to moderately stained than in *I. persica* var. *purpurea,* and somewhat greater than in *I. sindjarensis.*

With *safranin,* the grains, as in the parents, stain very lightly at once, and in 30 minutes they are moderately colored (value 45), 5 units less than in *I. persica* var. *purpurea,* and 2 units less than in *I. sindjarensis.*

In the reactions with aniline stains *I. pursind* shows a closer relationship to *I. sindjarensis* than to *I. persica* var. *purpurea.*

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 64.5° to 66° C., and of all is 68° to 70° C., mean 69° C. The temperature of gelatinization of *I. pursind* is the same as that of *I. persica* var. *purpurea,* and 2.5° C. higher than that of *I. sindjarensis.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 1 minute. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 12 per cent of the grains and 15 per cent of the total starch in 15 minutes; in about 21 per cent of the grains and 28 per cent of the total starch in 30 minutes; in about 33 per cent of the grains and 36 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 442.)

The hilum is as distinct as in *I. persica* var. *purpurea,* and a bubble is nearly as often formed there as in that starch. The lamellæ as in *I. persica* var. *purpurea* are at first indistinct but later become distinct; and the grain becomes refractive during the reaction as in *I. persica* var. *purpurea.* Gelatinization begins at the distal margin, usually at small cracks or fissures in the margin as in *I. persica* var. *purpurea,* but sometimes in the elongated forms at the distal corners as in *I. sindjarensis,* and the progress of gelatinization is distinctly closer to that described under *I. persica* var. *purpurea,* although there seems to be some tendency for the surface starch to be less resistant than that of the interior as in *I. sindjarensis.* The gelatinized grains have thicker capsules than in *I. persica* var. *purpurea,* but not so thick as in *I. sindjarensis,* but they are as distorted and bear as little resemblance to the form of the untreated grain as in that starch. In this reaction *I. pursind* shows qualitatively a closer relationship to *I. persica* var. *purpurea* than to *I. sindjarensis.*

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 12 per cent of the total starch in 5 minutes; in about 28 per cent of the grains and 85 per cent of the total starch in 15 minutes; in about 43 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 54 per cent of the grains and 92 per cent of the total starch in 45 minutes; in about 74 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 443.)

The reaction with *pyrogallic acid* begins in 30 minutes. Complete gelatinization occurs in about 25 per cent of the entire number of grains and 82 per cent of the total starch in 5 minutes; in about 82 per cent of the grains and 99 per cent of the total starch in 15 minutes; in about 95 per cent of the grains and in more than 99 per cent of the total starch in 30 minutes. (Chart D 444.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 39 per cent of the entire number of grains and 87 per cent of the total starch in 5 minutes; in about 71 per cent of the grains and 98 per cent of the total starch in 15 minutes; in

about 93 per cent of the grains and in more than 99 per cent of the total starch in 30 minutes; very little if any further advance in 45 and 60 minutes, respectively. (Chart D 445.) The margin of a very small percentage of grains is quite resistant, less than in both parents.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 94 per cent of the entire number of grains and in more than 99 per cent of the total starch in 2 minutes; in 100 per cent of the grains and total starch in 5 minutes. (Chart D 446.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 75 per cent of the entire number of grains and 95 per cent of the total starch in 5 minutes; in about 95 per cent of the grains and in more than 99 per cent of the total starch in 15 minutes. (Chart D 447.)

The hilum is as distinct and a bubble is as often formed there as in *I. persica* var. *purpurea.* The lamellæ also are as distinct as in *I. persica* var. *purpurea.* Gelatinization, as in the parents, begins at the hilum, and there are two methods of procedure, and in both the grains show a closer resemblance to *I. persica* var. *purpurea* than to *I. sindjarensis,* although the striæ which radiate from the hilum to the margin are finer, and in some grains not visible, nor are the granules formed at the margin so large. The gelatinized grains are very much swollen and have thinner capsules and are more distorted than in *I. persica* var. *purpurea;* but the capsules are not so thin and the grains are on the average not so much distorted as in *I. sindjarensis.* In this reaction *I. pursind* shows qualitatively a somewhat closer relationship to *I. persica* var. *purpurea* than to *I. sindjarensis.*

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 46 per cent of the entire number of grains and 95 per cent of the total starch in 5 minutes; in about 64 per cent of the grains and 98 per cent of the total starch in 15 minutes; in about 73 per cent of the grains and more than 99 per cent of the total starch is gelatinized in 30 minutes; little if any further advance in 45 and 60 minutes, respectively. (Chart D 448.)

A delicate, complete or partial layer at the margin of a small percentage of grains is quite resistant as in the parents. At 5 minutes fewer entire grains remain ungelatinized than in both parents.

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 90 per cent of the entire number of grains and 99 per cent of the total starch in 5 minutes; in about 95 per cent of the grains and more than 99 per cent of the total starch in 15 minutes. (Chart D 449.)

The hilum is as distinct as in the parents, and there are as many bubbles formed there as in *I. sindjarensis.* The lamellæ are, as a rule, not distinct, as in *I. persica* var. *purpurea.* Gelatinization as in the parents begins at the hilum and the process is somewhat nearer that described under *I. persica* var. *purpurea,* though the striæ are finer, but not so fine as in *I. sindjarensis,* and there is not so much granulation and fissuration as in *I. persica* var. *purpurea,* but more than in *I. sindjarensis.*

The gelatinized grains are somewhat less swollen than in *I. persica* var. *purpurea,* with somewhat thicker capsules, and not so much distorted as in *I. persica* var. *purpurea,* but more than in *I. sindjarensis.*

In this reaction *I. pursind* shows qualitatively a somewhat closer relationship to *I. persica* var. *purpurea* than to *I. sindjarensis.*

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 80 per cent of the entire number of grains and in more than 99 per cent of the total starch in 2 minutes; in about 92 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 450.)

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 12 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 16 per cent of the total starch in 15 minutes; in about 6 per cent of the grains and 22 per cent of the total starch in 30 minutes; in about 8 per cent of the grains and 23 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 451.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 73 per cent of the entire number of grains and 97 per cent of the total starch in 2 minutes; in about 97 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 452.)

The hilum and the lamellæ are as distinct as in *I. persica* var. *purpurea* and there are more grains which, before the reagent is added, have 2 refractive fissures extending from the hilum on either side toward the distal margin. Gelatinization begins at the hilum as in both parents and follows the two types described under *I. persica* var. *purpurea,* which are also seen, with modification, in *I. sindjarensis.* The main differences noted in the hybrid are that the starch near the hilum is somewhat more often fissured and divided into granules than in *I. persica* var. *purpurea,* but less often than in *I. sindjarensis;* and there is a greater number of grains which show the second type of gelatinization than in either parent, which constitutes an accentuation of a process more characteristic of *I. persica* var. *purpurea* than of *I. sindjarensis.* The gelatinized grains are as much swollen, have nearly as thick capsules, and are, as a rule, approximately as much distorted as in *I. persica* var. *purpurea.*

In this reaction *I. pursind* shows qualitatively a somewhat closer relationship to *I. persica* var. *purpurea* than to *I. sindjarensis,* but resembles both parents closely. A character noted in one parent may be accentuated in the hybrid.

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 37 per cent of the entire number of grains and 73 per cent of the total starch in 5 minutes; in about 73 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 88 per cent of the grains and 99 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes. (Chart D 453.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 21 per cent of the entire number of grains and 33 per cent of the total starch in 5 minutes; in about 50 per cent of the grains and 62 per cent of the total starch in 10 minutes;

in about 75 per cent of the grains and 79 per cent of the total starch in 15 minutes; in more than 99 per cent of the grains and total starch in 30 minutes. (Chart D 454.)

The hilum is as distinct as in *I. persica* var. *purpurea*, and a small bubble is not so often formed there as in that starch, but more often than in *I. sindjarensis*. The lamellæ are as distinct as in *I. persica* var. *purpurea*. The grains become more refractive in appearance when the reagent is added, and the first part to show this increased refractivity is a rather narrow band about the margin, as in *I. persica* var. *purpurea*. Gelatinization begins at separate points on the distal margin, which has previously been invaded by short, wide cracks that are more numerous and deeper than in *I. persica* var. *purpurea*. The progress of gelatinization is not so smooth as in either parent, and there is more fissuring, and in some cases actual granulation of the starch just preceding gelatinization than in even *I. persica* var. *purpurea*. The gelatinized grains are much swollen, have as thin a capsule, and are as distorted as in *I. persica* var. *purpurea*.

In this reaction *I. pursind* shows qualitatively a closer relationship to *I. persica* var. *purpurea* than to *I. sindjarensis*. Phenomena characteristic of one parent are sometimes accentuated in the hybrid.

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 28 per cent of the total starch in 5 minutes; in about 37 per cent of the grains and 80 per cent of the total starch in 15 minutes; in about 58 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 70 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 85 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 455.)

The reaction with *uranium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 17 per cent of the total starch in 5 minutes; in about 44 per cent of the grains and 75 per cent of the total starch in 15 minutes; in about 63 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 70 per cent of the grains and 96 per cent of the total starch in 45 minutes; in about 77 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 456.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 9 per cent of the entire number of grains and 39 per cent of the total starch in 5 minutes; in about 65 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 93 per cent of the grains and in more than 99 per cent of the total starch in 30 minutes. (Chart D 457.)

The reaction with *cobalt nitrate* begins in 30 seconds. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 26 per cent of the total starch in 15 minutes; in about 7 per cent of the grains and 36 per cent of the total starch in 30 minutes; in about 9 per cent of the grains and 43 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 44 per cent of the total starch in 60 minutes. (Chart D 458.)

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 7 per cent of the entire number of grains and 43 per cent of the total starch in 5 minutes; in about 45 per cent of the grains and 80 per cent of the total starch in 15 minutes; in about 72 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 74 per cent of the grains and 97 per cent of the total starch in 45 minutes; in about 80 per cent of the grains and 99 per cent of the total starch in 60 minutes. (Chart D 459.)

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 16 per cent of the grains and 49 per cent of the total starch in 5 minutes; in about 56 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 85 per cent of the grains and in more than 99 per cent of the total starch in 30 minutes; in about 90 per cent of the grains and in more than 99 per cent of the total starch in 45 minutes. (Chart D 460.)

The reaction with *barium chloride* begins in a few grains in 1 minute. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 12 per cent of the total starch in 15 minutes; in about 6 per cent of the grains and 22 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 27 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 31 per cent of the total starch in 60 minutes. (Chart D 461.)

The reaction with *mercuric chloride* begins immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 35 per cent of the total starch in 5 minutes; in about 45 per cent of the grains and 82 per cent of the total starch in 15 minutes; in about 65 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 68 per cent of the grains and 97 per cent of the total starch in 45 minutes; little if any farther advance in 60 minutes. (Chart D 462.)

A larger percentage of the grains are gelatinized with the exception of the margin than in the parents, but there are fewer entire grains which are resistant than in the parents; hence, the percentages of gelatinization of the grains and total starch show a greater variation than in the parents.

9. GLADIOLUS.

This genus of iridaceous, cormous, or bulbous plants includes about 140 species, mostly natives of Cape Colony and Natal. About 15 species are natives of the Mediterranean region, and a few have been found in the mountains of tropical Africa. Most of the cultivated forms are species or hybrids referable to the South American group and represented chiefly by *G. cardinalis*, *G. floribundus*, *G. psittacinus*, and *G. blandus*. *Gladiolus* and *Tritonia* are closely related genera. (See *Tritonia*.)

Starches of the following parent-stocks and hybrid-stock were studied:

34. *G. cardinalis* Curt. (seed parent), *G. tristis* Linn. (pollen parent), and *G. colvillei* (hybrid).

The specimens were obtained from E. H. Krelage and Son, Haarlem, Holland.

34. Starches of Gladiolus cardinalis, G. tristis, and G. colvillei.

Gladiolus cardinalis (Seed Parent).

(Plate 20, fig. 115; Charts D 463 to D 483.)

Histologic Properties.

In *form* most of the grains are simple and appear as aggregates of usually 2 to 6, rarely 12, components, with the exception of a few which are separated components of aggregates or have remained isolated throughout their life-history. Compound grains consisting usually of 2 components inclosed in a few common lamellæ are occasionally observed. Sharply defined pressure facets are present on the separated grains. The surface of the grains is usually regular, but occasionally there is found either a slight, rounded elevation, or reticular markings at some point, the latter probably indicating the previous attachment of small grains to a large one. The conspicuous forms of the aggregates (composed usually of about equal-sized components) are ellipsoidal, nearly round, rounded triangular, and rounded quadrangular. In addition there are aggregates of 1 large and 1 or more small components, and rarely aggregates with components in linear arrangement in the form of a straight or slightly bent rod with curved ends. The conspicuous forms of the few separated grains are dome-shaped with either squared or pointed base, and polygonal. The conspicuous forms of the permanently isolated grains are round, nearly round, and ellipsoidal. The grains are not flattened.

The *hilum* is a small, round, oval, or lenticular, usually non-refractive, spot. Multiple hila are occasionally found. A small rounded cavity, a short transverse cleft, or a group of clefts occasionally appear at the hilum. The clefts are usually arranged in a soaring-bird, a cruciate, or a thorn-shaped figure. Fissures which pass obliquely towards the distal corners of the grains frequently proceed from the hilum. The hilum is either centric or has a range of eccentricity from 0.45 to 0.35, commonly about 0.4, of the longitudinal axis.

The *lamellæ* are not always demonstrable, but are moderately distinct in some of the grains. The lamella nearest the hilum usually is found in the form of a circular ring but the remainder follow the outline of the grain. They are moderately fine—often with one somewhat more distinct and coarser, located at varying distances from the hilum. Occasionally a refractive marginal border or a rounded elevation at some point on the grain is observed in which the lamellæ are not always demonstrable, but, when made out, they are coarser and more sharply defined than those of the main body of the grain. These lamellæ probably represent a secondary set. The number of lamellæ on the larger permanently isolated and component grains ranges from 10 to 14 on the components of aggregates more often 8 to 10.

The *size* of the grains varies from the smaller isolated grains which are 3 by 2μ, to the larger permanent isolated grains which are 26 by 25μ, and the larger aggregates of the more common doublet type 48 by 36μ, in length and breadth. The common size of the permanent isolated is about 22 by 20μ, and the common size of the doublet is about 34 by 20μ in length and breadth.

Polariscopic Properties.

The *figure* varies from centric to quite eccentric, with more of the former, and is usually distinct and clean-cut. The lines are fine and many intersect either at a right angle or obliquely—more figures with former arrangement. In the figures of the isolated grains the lines are usually straight, but in the numerous double and multiple figures they are frequently bent and bisected.

The *degree of polarization* is high to very high (value 85). There is considerable variation in the different grains, and occasionally a slight variation in the same aspect of a given grain.

With *selenite* the quadrants are sharply defined, and are often slightly unequal in size and irregular in shape, but are regular and equal in some of the grains, especially the permanently isolated ones. The colors are usually pure, but occasionally indicate impurity by a greenish tinge to both colors.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains color a moderate to deep (value 60) blue-violet which becomes bluer in tint as it deepens rapidly. With 0.125 per cent Lugol's solution the grains color a light blue-violet, some of which deepen moderately rapidly, while others show very little if any change. After heating in water until all the grains are gelatinized and then adding 2 per cent Lugol's solution, most of the gelatinized *grains* color a light to moderately deep indigo-blue, with a few moderately deep, and the *solution* a moderately deep indigo-blue. If the preparation is boiled for 2 minutes, and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* color a deep blue with reddish tint, most of the capsules a deep heliotrope and some wine-red, and the *solution* a very deep indigo-blue.

Aniline Reactions.

With *gentian violet* the grains stain very lightly at once, and in half an hour they are moderately colored (value 50), and an occasional grain having a delicate border of deeper color, deeper than in *G. tristis*.

With *safranin* the grains stain lightly at once, and in half an hour they are moderately colored (value 53), and an occasional grain with a delicate border of deeper color as in reaction with gentian violet. The color with this stain is a little deeper than with gentian violet, and deeper than in *G. tristis*.

Temperature Reactions.

The majority of the grains are gelatinized at 83° to 84.5° C., and of all at 84° to 86° C., mean 85° C., distinctly higher than in *G. tristis*.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 14 per cent of the grains and 22 per cent of the total starch in 5 minutes; in about 36 per cent of the grains and 45 per cent of the total starch in 15 minutes; in about 48 per cent of the grains and 51 per cent of the total starch in 30 minutes; in about 49 per cent of the grains and 52 per cent of the total starch in 45 minutes; in about 51 per cent of the grains and 53 per cent of the total starch in 60 minutes. (Chart D 463.)

The hilum becomes very prominent and there is usually a small bubble formed. From the hilum to the distal corners of the grain are two lines or canals which appear to divide the material of the grain into two portions. The lamellæ, which are not distinct at first, later become moderately distinct and may be seen to be transversed by fine radiating lines. A refractive band is slowly formed and surrounds a part of the margin of the grain. It is narrow and appears to be confined to the margin. Gelatinization begins at the distal margin, usually at the corners of the pressure facets. The simple grains are most quickly and most frequently affected, many of the compound grains and of the aggregates not being gelatinized at all; in those which are gelatinized, however, gelatinization begins at the distal margin of the components as in the case of the simple grains. After this preliminary gelatinization, the fine radiating lines before noted become larger and divide the lamellæ into rows of granules, the hilum swells, and the granules are pushed to the margin and then gelatinized, and as the starch between the hilum and the distal margin is the most resistant part of the grain it is gelatinized last. The gelatinized grains are large and somewhat distinct, but still retain some of the original form of the grain.

The reaction with *chromic acid* begins in a few grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 20 per cent of the total starch in 15 minutes; in about 25 per cent of the grains and 75 per cent of the total starch in 30 minutes; in about 28 per cent of the grains and 90 per cent of the total starch in 45 minutes; in about 53 per cent of the grains and 96 per cent of the total starch in 60 minutes. (Chart D 464.)

The reaction with pyrogallic acid begins in a few grains in half a minute. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 10 per cent of the total starch in 15 minutes; very slight advance in 30 minutes; in about 8 per cent of the grains and 12 per cent of the total starch in 45 minutes; about the same in 60 minutes. (Chart D 465.)

The reaction with *nitric acid* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 4 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 6 per cent of the total starch in 30 minutes; in about 4 per cent of the grains and 8 per cent of the total starch in 45 minutes; in about the same percentage of both the grains and total starch in 60 minutes. (Chart D 466.)

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 44 per cent of the entire number of grains and 81 per cent of the total starch in 5 minutes; in about 70 per cent of the grains and 97 per cent of the total starch in 15 minutes; in about 86 per cent of the grains and over 99 per cent of the total starch in 30 minutes; in about 99 per cent of the grains and over 99 per cent of the total starch in 45 minutes. (Chart D 467.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 12 per cent of the total starch in 5 minutes; in about 7 per cent of the grains and 22 per cent of the total starch in 15 minutes; in about 12 per cent of the grains and 32 per cent of the total starch in 30 minutes; in about 15 per cent of the grains and 52 per cent of the total starch in 45 minutes; in about 20 per cent of the grains and 68 per cent of the total starch in 60 minutes. (Chart D 468.)

Gelatinization in many grains begins simultaneously at the margin and in the mesial region. When the margin is affected the capsule becomes much distended and thrown into folds, and after the process has progressed inward through a narrow border this delicate folded area appears to dissolve. The process of gelatinization is now more rapid along the courses of fissures which proceed from the hilum, causing the mesial region to be disorganized into very refractive granules surrounded by a few lamellæ which are profusely striated. At the end of the experiment (60 minutes) the grains are much swollen, but only a comparatively small percentage are completely gelatinized, the majority having the mesial region bounded by a border of ungelatinized lamellæ. The smaller and medium-sized grains are to a larger extent gelatinized, and sometimes become disintegrated and rarely dissolved.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 11 per cent of the total starch in 5 minutes; in about 7 per cent of the grains and 14 per cent of the total starch in 15 minutes; in about 12 per cent of the grains and 22 per cent of the total starch in 30 minutes; in about 20 per cent of the grains and 28 per cent of the total starch in 45 minutes; in about 24 per cent of the grains and 32 per cent of the total starch in 60 minutes. (Chart D 469.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 12 per cent of the total starch in 15 minutes; in about 9 per cent of the grains and 15 per cent of the total starch in 30 minutes; in about the same percentage of the grains but about 19 per cent of the total starch in 45 minutes; in about 12 per cent of the grains and 22 per cent of the total starch in 60 minutes. (Chart D 470.)

The hilum becomes very distinct, as do also 2 or 3 canals or fissures from the hilum to the distal corners of the pressure facets. The lamellæ are visible but somewhat indistinct. Gelatinization begins at the hilum, and after enlargement of the hilum begins, very fine striæ are seen radiating out to the margin, which, as the hilum continues to increase in size, become coarser, separating the grain into spicules and pushing them farther apart, so that there is formed a central gelatinized mass bordered by a fringed band of more resistant starch at the margin. This band becomes progressively narrower and more nearly transparent until gelatinization is complete. This process, however, is completed in but few grains, and one may see all stages after 1 hour.

There are a few grains with an especially rapidly reacting outer layer, and in these there may occur a rapid swelling and gelatinization of the outer layer, followed by the process described above in the rest of the grain.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 11 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 22 per cent of the total starch in 15 minutes; in about 14 per cent of the grains and 27 per cent of the total starch in 30 minutes; in about 19 per cent of the grains and 35 per cent of the total starch in 45 minutes; in about 24 per cent of the grains and 41 per cent of total starch in 60 minutes. (Chart D 471.)

The reaction with *potassium sulphide* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 6 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes. (Chart D 472.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 11 per cent of the total starch in 5 minutes; in about 10 per cent of the grains and 16 per cent of the total starch in 15 minutes; in about 16 per cent of the grains and 24 per cent of the total starch in 30 minutes; in about 20 per cent of the grains and 32 per cent of the total starch in 45 minutes; in about 24 per cent of the grains and 40 per cent of the total starch in 60 minutes. (Chart D 473.)

The hilum becomes very distinct and 2 canals or fissures are seen to extend from the hilum to the distal pressure-facet corners. The lamellæ are not visible before or at the beginning of gelatinization, but later become moderately distinct. Gelatinization starts at the hilum which begins to enlarge. The grain becomes divided into a mass of spicules extending from the hilum to the margin, by a great number of coarse striæ, which enlarge and separate the spicules more and more as gelatinization progresses.

The grain swells as the hilum enlarges and the ends of the spicules of starch nearest the hilum are gelatinized. Finally, all the ungelatinized starch, with the exception of a few granules scattered in the interior of the grain, is collected at the margin where it remains as a thick, striated band, which gradually becomes thinner and more nearly transparent, and more and more gelatinous. The gelatinized grains have rather thick capsules, and are moderately large and somewhat distorted, but retain much of the form of the untreated grain.

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 10 per cent of the total starch in 15 minutes; in about 6 per cent of the grains and 13 per cent of the total starch in 30 minutes; in about 10 per cent of the grains and 19 per cent of the total starch in 45 minutes; in about 16 per cent of the grains and 26 per cent of total starch in 60 minutes. (Chart D 474.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 46 per cent of the grains and 50 per cent of the total starch in 5 minutes; in about 94 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 98 per cent of both the grains and total starch in 45 minutes; in about 99 per cent of the grains and over 99 per cent of total starch in 60 minutes. (Chart D 475.)

The hilum becomes distinct and a bubble is often found there, and in some of the more resistant grains the lamellæ also become distinct. Gelatinization begins at the hilum and is preceded by the appearance of a great number of very fine striæ radiating from the hilum to the margin of the grain. The hilum then begins to enlarge and the bubble, if present, enlarges, then shrinks and disappears, the proximal starch gelatinizes, followed by the distal portion. The gelatinization is carried out without any obvious fissuring or granulation of the starch. The aggregates and the compound grains are more resistant than the simple grains, which, as a rule, gelatinize very quickly. The gelatinized grains are moderately large and somewhat distorted, but retain much of their original form.

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 8 per cent of the total starch in 15 minutes; in about 6 per cent of the grains and 9 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes. (Chart D 476.)

The reaction with *uranium nitrate* begins in rare grains immediately. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about the same percentage of the grains and 4 per cent of the total starch in 30 minutes; in about the same percentage of both the grains and total starch in 45 and 60 minutes. (Chart D 477.)

The reaction with *strontium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 12 per cent of the total starch in 15 minutes; in about 15 per cent of the grains and 22 per cent of the total starch in 30 minutes; in about 18 per cent of the grains and 24 per cent of the total starch in 45 minutes; in about 20 per cent of the grains and 26 per cent of total starch in 60 minutes. (Chart D 478.)

The reaction with *cobalt nitrate* begins immediately in a few smaller grains and in rare larger grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 30 minutes; little if any further advance is observed in 45 and 60 minutes. (Chart D 479.)

A few of the smaller grains are quickly gelatinized, while very few of the larger grains, probably not more than 0.5 per cent, are gelatinized in 60 minutes.

The reaction with *copper nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 4 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 6 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 7 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 8 per cent of the total starch in 60 minutes. (Chart D 480.)

The reaction with *cupric chloride* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 6 per cent of the total starch in 30 minutes; in about 5 per cent of the grains and 7 per cent of the total starch in 45 minutes; in about the same percentage of both grains and total starch in 60 minutes. (Chart D 481.)

The reaction with *barium chloride* begins in a few small grains immediately. Complete gelatinization occurs in about 0.5 per cent of the grains and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes. (Chart D 482.) A few of the smaller grains and an occasional medium-sized grain are gelatinized, the larger typical grains being slightly if any gelatinized by the reagent.

The reaction with *mercuric chloride* begins in a few of the smaller grains immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about the same percentage of the grains and 5 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 6 per cent of the total starch in 30 minutes; little if any advance in 45 and 60 minutes. (Chart D 483.) Only the smaller grains and rare grains of medium size undergo complete or partial gelatinization.

Gladiolus tristis (Pollen Parent).

(Plate 20, fig. 116; Charts D 463 to D 483.)

Histologic Properties.

In *form* the grains are simple and appear as separated grains of aggregates, or arranged either in partially disintegrated or rare complete aggregates of from 2 to 4 components. Doubtless aggregates of more components have existed, since polygonal grains with at least 5 angles are found. A few originally simple isolated grains are present. No compound grains were observed. Sharply defined pressure facets are noted on most of the grains, many more than in *G. cardinalis,* since the number of separated grains are much more numerous. The surface of the grains is regular, unless pressure facets may be regarded irregularities; no rounded elevations or reticular markings were observed. The conspicuous forms of the rare aggregates, as well as the numerous separated and the few isolated grains, are the same as in *G. cardinalis.* In addition, an aggregate consisting of one large and one or more small components is found as in *G. cardinalis,* but no components in linear arrangement were observed as appeared to be rarely present in *G. cardinalis.* The grains like those of *G. cardinalis* are not flattened.

The *hilum,* as a rule, is not distinct, much less so than in *G. cardinalis,* but when observed is a round, oval, or lenticular, non-refractive spot. Multiple hila are not observed. Sometimes either a rounded or an irregular cavity is found at the hilum, often larger and more irregular than in *G. cardinalis.* A short transverse cleft or clefts, usually arranged in T, Y, and stellate figures, are sometimes found at the hilum. Fissures frequently proceed from the hilum which pass obliquely towards the distal corners of the grain. The fissures at and proceeding from the hilum are present in more grains than in *G. cardinalis.* The hilum is either centric, or has a range of eccentricity from 0.45 to 0.25, commonly about 0.35, of the longitudinal axis.

The *lamellæ* are usually not demonstrable and not so distinct as in *G. cardinalis.* When observed they have the same structure as noted for *G. cardinalis.* They can more often be counted on the round isolated grains; the number on the larger grains is 8 to 10, less numerous than in *G. cardinalis.*

The *size* of the grains varies from the smaller isolated ones, which are 3 by 2μ, to the larger permanent isolated, which are about 22 by 22μ, and the larger separated dome-shaped components (no large aggregates found), which are 24 by 24μ, in length and breadth. The common size of the permanent isolated grains is about 18 by 16μ, and the separated dome-shaped component is about 18 by 18μ. The sizes are, on the whole, less than in *G. cardinalis.*

Polariscopic Properties.

The *figure* varies from centric to quite eccentric, with more of the former, the mean is slightly more eccentric than in *G. cardinalis;* it is not distinct in some of the grains, and less clean-cut and distinct than in *G. cardinalis.* The lines vary from fine to coarse, the mean being coarser than in *G. cardinalis,* but they intersect as in that species. They are usually straight, not being bent nor bisected as often as in *G. cardinalis.* Rare double and multiple figures are observed, but they are not nearly so numerous as in *G. cardinalis.*

The *degree of polarization* is moderate to high (value 65), lower than in *G. cardinalis.* There is somewhat more variation in the different grains, and much greater in the same aspect of a given grain, than in *G. cardinalis.*

With *selenite* the quadrants are moderately well defined, but not so clean-cut as in *G. cardinalis.* They are often slightly irregular in shape and unequal in size, in somewhat more grains than in *G. cardinalis.* The colors are pure in the majority of grains, but often show im-

purity due to a purplish and orange tint very rarely to a greenish tint, the impurity of the colors being due to the latter in *G. cardinalis.* The colors are less pure than in *G. cardinalis.*

Iodine Reactions.

With 0.25 per cent Lugol's solution, the grains color a moderate to deep blue-violet (value 60), which deepens rapidly, of the same depth but more reddish in tint than in *G. cardinalis.* With 0.125 per cent Lugol's solution, the grains color a light blue-violet, which deepens more rapidly with less variation in the different grains, so that the mean is deeper in color as well as slightly more reddish in tint than in *G. cardinalis.* After heating in water until all the grains are gelatinized, and then adding a 2 per cent Lugol's solution, the *grains* color a moderate to moderately deep blue, with many more of the latter, which also have a slight reddish tint; the gelatinized grains are deeper and more reddish in tint, and the *solution* about the same as in *G. cardinalis.* If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* color a deep reddish purple, and most of the *capsules* a light old-rose to wine-red, while a few are heliotrope in color. Both the capsules and the grain-residues are more reddish in tint, and the mean of the former somewhat lighter, than in *G. cardinalis;* the *solution* is about the same as in *G. cardinalis.*

Aniline Reactions.

With *gentian violet* the grains stain very lightly at once, and in half an hour they deepen slightly but are light to moderately colored (value 40), lighter than in *G. cardinalis.* The delicate border of deeper color occasionally noted in *G. cardinalis* is not observed.

With *safranin* the grains stain lightly at once, and in half an hour they deepen somewhat, becoming light to moderate in color (value 45), deeper than in the reaction with gentian violet. The color is a little lighter than in *G. cardinalis.* The border noted in occasional grains of *G. cardinalis* is not observed.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is at 76° to 78° C., and of all at 78° to 79° C., mean 78.5° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 30 per cent of the entire number of grains and 39 per cent of the total starch in 5 minutes; in about 39 per cent of the grains and 47 per cent of the total starch in 15 minutes; in about 45 per cent of the grains and 53 per cent of the total starch in 30 minutes; in about 49 per cent of the grains and 54 per cent of the total starch in 45 minutes; in about 50 per cent of the grains and 55 per cent of the total starch in 60 minutes. (Chart D 463.)

The hilum becomes very prominent, and an occasional bubble is formed there. The two lines or canals which go from the hilum to the distal corners of the grain, and which are seen in *G. cardinalis,* also appear here but not so distinctly. The lamellæ are not distinct and in many grains are not visible. A refractive band is formed at the margin of some of the grains, but it is narrow and confined to the margin. Gelatinization begins at the hilum, or at the distal corners of the pressure facets, or at all points on the margin. In the first method the hilum swells and pushes the ungelatinized material to the margin where it is seen to be divided into granules by fine radiating lines, and these granules are slowly gelatinized; in the second, the process is similar to that noted under *G. cardinalis;* and in the third, the process advances inward over the grain until the hilum is reached, which suddenly swells very greatly. The gelatinized grains are considerably enlarged and distorted and show little of the original form of the grain.

The reaction with *chromic acid* begins in a few grains in 1 minute. Complete gelatinization occurs in about 1 per cent of the grains and 13 per cent of the total starch in 5 minutes; in about 33 per cent of the grains and 60 per cent of the total starch in 15 minutes; in about 79 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 90 per cent of the grains and 98 per cent of the total starch in 45 minutes; in about 98 per cent of the grains and over 99 per cent of the total starch in 60 minutes. (Chart D 464.)

The reaction with *pyrogallic acid* begins in a few grains immediately. Complete gelatinization occurs in about 7 per cent of the grains and 14 per cent of the total starch in 5 minutes; in about 20 per cent of the grains and 75 per cent of the total starch in 15 minutes; in about 31 per cent of the grains and 81 per cent of the total starch in 30 minutes; in about 42 per cent of the grains and 90 per cent of the total starch in 45 minutes; in about 50 per cent of the grains and 95 per cent of the total starch in 60 minutes. (Chart D 465.)

The reaction with *nitric acid* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 12 per cent of the total starch in 15 minutes; in about 11 per cent of the grains and 15 per cent of the total starch in 30 minutes; in about 11 per cent of the grains and 17 per cent of the total starch in 45 minutes; in about 12 per cent of the grains and 21 per cent of the total starch in 60 minutes. (Chart D 466.)

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 52 per cent of the grains and 86 per cent of the total starch in 5 minutes; in about 86 per cent of the grains and over 99 per cent of the total starch in 15 minutes; in about 97 per cent of the grains and over 99 per cent of the total starch in 30 minutes; complete gelatinization (100 per cent) of all grains in 45 minutes. (Chart D 467.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 23 per cent of the entire number of grains and 45 per cent of the total starch in 5 minutes; in about 40 per cent of the grains and 68 per cent of the total starch in 15 minutes; in about 51 per cent of the grains and 77 per cent of the total starch in 30 minutes; in about 51 per cent of the grains and 83 per cent of the total starch in 45 minutes; in about 64 per cent of the grains and 85 per cent of the total starch in 60 minutes. (Chart D 468.)

Gelatinization begins and proceeds as in *G. cardinalis,* the margin being more frequently attacked, accompanied by great distention, than in this species. At the end of the experiment (60 minutes) the majority are

gelatinized and many are either undergoing disintegration or have passed into solution—a much larger percentage in each case than noted for *G. cardinalis.* The region of the facets is the most resistant, the capsule at other parts frequently being either slit at many points or completely dissolved. The most resistant grains are the scattered larger globular and dome-shaped grains.

The grains are swollen and generally, if not completely gelatinized, retain only a single lamella at the margin which is either profusely striated or broken down into linear granules, the process having proceeded much farther in all the grains, with exception of the few scattered grains above mentioned, in which progress is about the same as in *G. cardinalis.*

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 13 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 18 per cent of the total starch in 15 minutes; in about 16 per cent of the grains and 25 per cent of the total starch in 30 minutes; in about 22 per cent of the grains and 30 per cent of the total starch in 45 minutes; in about 31 per cent of the grains and 37 per cent of the total starch in 60 minutes. (Chart D 469.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 8 per cent of the total starch in 5 minutes; in about 9 per cent of the entire number of grains and 21 per cent of the total starch in 15 minutes; in about 20 per cent of the entire number of grains and 50 per cent of the total starch in 30 minutes; in about 25 per cent of the grains and 58 per cent of the total starch in 45 minutes; in about 31 per cent of the grains and 65 per cent of the total starch in 60 minutes. (Chart D 470.)

The hilum is not so distinct as in *G. cardinalis.* The lamellæ are visible and in some grains are less indistinct than in *G. cardinalis.* Gelatinization begins at the hilum, and the process is very similar to that noted in *G. cardinalis,* except that the whole process is much more rapid, and the fine striæ radiating from the hilum are usually not distinctly seen until near the end when they become very prominent; later the starch at the margin is divided into a number of coarse granules which gradually become more transparent and are finally gelatinized. There are many more completely gelatinized grains than in *G. cardinalis,* and they are large and somewhat distorted, but have some of the form of the untreated grain. There are some grains noted here that have a more quickly reacting outer layer as in *G. cardinalis.*

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 18 per cent of the total starch in 5 minutes; in about 25 per cent of the grains and 86 per cent of the total starch in 15 minutes; in about 61 per cent of the grains and 93 per cent of the total starch in 30 minutes; in about 64 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 64 per cent of the grains and 97 per cent of total starch in 60 minutes. (Chart D 471.)

The reaction with *potassium sulphide* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; slight advance in 15 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 30 minutes; in about 4 per cent of the grains and 6 per cent of the total starch in 45 minutes; in about the same percentage of both the grains and total starch in 60 minutes. (Chart D 472.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 15 per cent of the entire number of grains and 25 per cent of the total starch in 5 minutes; in about 22 per cent of the grains and 35 per cent of the total starch in 15 minutes; in about 35 per cent of the grains and 50 per cent of the total starch in 30 minutes; in about 50 per cent of the grains and 63 per cent of the total starch in 45 minutes; in about 50 per cent of the grains and 68 per cent of the total starch in 60 minutes. (Chart D 473.)

The hilum becomes somewhat less distinct than in *G. cardinalis,* and the lamellæ appear sometimes very clearly as gelatinization progresses. Gelatinization begins at the hilum, and the process is similar to that described under *G. cardinalis,* except that the striæ radiating from the hilum are not so distinct as in that starch, nor are the granules which tend to persist in the interior of the gelatinized grain so often seen. The gelatinized grains are large and their walls are not so thick as those of *G. cardinalis;* they are also somewhat more distorted.

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 8 per cent of the total starch in 5 minutes; in about 10 per cent of the grains and 18 per cent of the total starch in 15 minutes; in about 24 per cent of the grains and 34 per cent of the total starch in 30 minutes; in about 36 per cent of the grains and 58 per cent of the total starch in 45 minutes; in about 40 per cent of the grains and 70 per cent of the total starch in 60 minutes. (Chart D 474.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 52 per cent of the entire number of grains and 64 per cent of the total starch in 5 minutes; in about 88 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 99 per cent of the grains and over 99 per cent of the total starch in 30 minutes. (Chart D 475.)

The hilum becomes distinct and a bubble is moderately often formed there, not so often as in *G. cardinalis,* and two lines are formed from the hilum to the corners of the pressure facets. The lamellæ are not visible. Gelatinization begins at the hilum in the less resistant grains and at the distal corners of the pressure facets in the more resistant grains. In the first-named grains gelatinization progresses in the same way as in *G. cardinalis;* in the second, the grain lengthens transversely as the hilum and the fissures or canals connecting it with the distal corners swell and lengthen. By this swelling the grain is divided into two parts, distal and proximal, of which the former is the first to be gelatinized. The gelatinized grains are moderately large and somewhat distorted, but retain much of their original form.

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 10 per cent of the total starch in 15 minutes; in about 9

per cent of the grains and 15 per cent of the total starch in 30 minutes; in about 9 per cent of the grains and 16 per cent of the total starch in 45 minutes; in about 9 per cent of the grains and 18 per cent of the total starch in 60 minutes. (Chart D 476.)

The reaction with *uranium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 6 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 8 per cent of the total starch in 30 minutes; in about 6 per cent of the grains and 9 per cent of the total starch in 45 minutes; in about the same percentage of both the grains and total starch in 60 minutes. (Chart D 477.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 9 per cent of the grains and 19 per cent of the total starch in 15 minutes; in about 19 per cent of the grains and 30 per cent of the total starch in 30 minutes; in about 32 per cent of the grains and 42 per cent of the total starch in 45 minutes; in about 37 per cent of the grains and 46 per cent of the total starch in 60 minutes. (Chart D 478.)

The reaction with *cobalt nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 0.5 per cent of the grains and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 30 minutes; little if any further advance occurs in 45 and 60 minutes, respectively. (Chart D 479.)

The reaction with *copper nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 8 per cent of the total starch in 15 minutes; in about 6 per cent of the grains and 11 per cent of the total starch in 30 minutes; in about 6 per cent of the grains and 13 per cent of the total starch in 45 minutes; in about 7 per cent of the grains and 14 per cent of total starch in 60 minutes. (Chart D 480.)

The reaction with *cupric chloride* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 6 per cent of the total starch in 30 minutes; in about 5 per cent of the grains and 8 per cent of the total starch in 45 minutes; in about 5 per cent of the grains and 10 per cent of the total starch in 60 minutes. (Chart D 481.)

The reaction with *barium chloride* begins in rare grains in half a minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and a slight advance of the total starch in 30 minutes; in about 3 per cent of the grains and 4 per cent of the total starch in 45 minutes; slight advance in the grains and about 5 per cent of total starch in 60 minutes. (Chart D 482.)

The reaction with *mercuric chloride* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 6 per cent of the total starch in 30 minutes; slight advance in the grains and 7 per cent of the total starch in 45 minutes; in about 5 per cent of the grains and 9 per cent of the total starch in 60 minutes. (Chart D 483.)

Gladiolus colvillei (Hybrid).

(Plate 20, fig. 117; Charts D 463 to D 483.)

Histologic Properties.

In *form* most of the grains are simple and appear as aggregates, usually of 2 to 8, rarely 14, components, with the exception of a few which are separated components of aggregates or have remained isolated throughout their life-history. A somewhat greater number of separated and permanent isolated grains are found than in *G. cardinalis;* not nearly so many separated grains, but more permanently isolated forms than in *G. tristis.* Compound grains of similar structure but in smaller numbers are found, as in *G. cardinalis,* which grains were not observed in *G. tristis.* Sharply defined pressure facets are more numerous than in *G. cardinalis*, but much less numerous than in *G. tristis.* The surface of the grains is usually regular. The same irregularities may be observed as noted for *G. cardinalis,* and they are more irregular than in *G. tristis.* Both the conspicuous and the additional forms of aggregates are the same as in *G. cardinalis;* and with the exception of those in linear arrangement, also the same as in *G. tristis.* The conspicuous forms of separated grains and original isolated grains are the same as in both parents, but a greater number of large rounded grains is present. The grains are not flattened. The grains of *G. colvillei* are slightly nearer to *G. cardinalis* in form. There is not much difference between the three starches.

The *hilum* is a small, round, oval, or lenticular spot which is slightly refractive, more refractive than in both parents. Multiple hila are occasionally observed as in *G. cardinalis.* The hilum is not fissured in most of the grains, but clefts are slightly more numerous than in both parents. A small rounded cavity is occasionally present as in *G. cardinalis,* it being, as a rule, somewhat smaller and more regular than in *G. tristis.* The cleft or clefts at the hilum and fissures proceeding from it are of similar character to those of both parents, and are more varied in arrangement than in either parent. The hilum is either centric or has a range of eccentricity from 0.45 to 0.25; commonly about 0.35, of the longitudinal axis.

In the eccentricity of the hilum the grains of *G. colvillei* are nearer to *G. tristis,* but in the general characters of the hilum they are nearer to *G. cardinalis.*

The *lamellæ* are not always demonstrable but are moderately distinct in some of the grains; they can not be seen in so many grains as in *G. cardinalis*, but are more distinct than in *G. tristis.* The structure and the arrangement are the same as in both parents, but the one more distinct and coarser lamella and the refractive border are demonstrable in more grains. The number of the larger permanently isolated grains ranges from 18

to 22, but on the component grains generally 10 to 14. In the characters of the lamellæ *C. colvillei* is midway between the parents, but in number it exceeds those of the parents.

The *size* of the grains varies from the smaller isolated ones, which are 4 by 3μ, to the larger permanently isolated which are 30 by 30μ, the larger doublets which are 44 by 30μ, and of the larger separated dome-shaped components which are 28 by 28μ, in length and breadth. The common size of the permanently isolated grains is about 24 by 22μ, of the doublet about 34 by 24μ, and of the dome-shaped component about 24 by 23μ. In size the grains of *G. covillei* are closer to *G. cardinalis* than to *G. tristis*.

Polariscopic Properties.

The figure varies from centric to quite eccentric, the mean is slightly greater than in *G. cardinalis*, the same as in *G. tristis*. The lines are fine and may intersect at right angle or obliquely with more of the former as in *G. cardinalis*, but they are not quite so often bent and bisected, while they are finer and more often bent and bisected than in *G. tristis*. Double and multiple figures are moderately numerous, but not found as frequently as in *G. cardinalis*, though much more numerous than in *G. tristis*.

The *degree of polarization* varies from high to very high (value 80), with not quite so many grains showing the latter as in *G. cardinalis*, hence the mean is somewhat lower, but much higher than in *G. tristis*. A slight variation may be found in the same aspect of a given grain as in *G. cardinalis*, but less than in *G. tristis*, while variation in the different grains is as in *G. cardinalis*, but somewhat less than in *G. tristis*.

With *selenite* the quadrants are sharply defined and often slightly unequal in size and irregular in shape, but in the larger permanently isolated grains they are more often equal and generally regular. The definition of the quadrants is about the same, but the mean somewhat more equal and regular than in *G. cardinalis*, while the definition is sharper, and the quadrants more equal and regular than in *G. tristis*. The colors are generally pure; although an occasional impurity due to a greenish tinge of both colors is found, they are pure in somewhat more grains than in *G. cardinalis* and in considerably more than in *G. tristis*.

In degree of polarization, in the character of the figure, and in the reaction with selenite the grains of *G. colvillei* are much closer to *G. cardinalis* than to *G. tristis*.

Iodine Reactions.

With 0.25 per cent Lugol's solution, the grains color a moderate blue-violet (value 55), which is a little lighter than in *G. cardinalis*, and as in *G. tristis* they deepen rapidly, becoming more bluish in tint but not quite as dark as in both parents and are less reddish in tint than in *G. tristis*. With 0.125 per cent Lugol's solution the grains color a light blue-violet, a trifle lighter than in *G. cardinalis*, and the same difference as noted with 0.25 per cent Lugol's solution with *G. tristis*, they deepen with the same variation, but the mean is not quite so dark as in *G. cardinalis*, while there is more variation, but not so much depth of color as in *G. tristis*. After heating in water until all the grains are gelatinized and then adding 2 per cent Lugol's solution, the majority of the gelatinized *grains* color light to moderate, with a few moderately deep blue; the color is of the same tint and depth as in *G. cardinalis*, but lighter and purer than in *G. tristis*; the *solution* becomes a moderately deep indigo-blue, about the same as in both parents. If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* become a deep blue with reddish tint, and the *capsules* a deep heliotrope to wine-red; both of about the same depth but slightly more reddish than in *G. cardinalis*, the grain-residues about the same depth, the mean of the capsules somewhat deeper, but both not nearly so reddish as in *G. tristis*. The *solution* has the same depth of color as in both parents.

Qualitatively and quantitatively the reactions with iodine are nearer to *G. cardinalis* than to *G. tristis*, and the quantitative reactions are lower than in either parent.

Aniline Reactions.

With *gentian violet* the grains color very lightly at once, and in half an hour they are moderately colored (value 47), though slightly lighter than in *G. cardinalis*, but deeper than in *G. tristis*. The delicate border of deeper color of occasional grains was noted as in *G. cardinalis*; this was not observed in *G. tristis*.

With *safranin* the grains stain lightly at once, and in half an hour they are moderately colored (value 53), though somewhat deeper than with gentian violet, the same as in *G. cardinalis*, but deeper than in *G. tristis*. The same delicate border of deeper color of occasional grains is seen, as in the reaction with gentian violet, and noted for *G. cardinalis*, but not for *G. tristis*.

The reactions with aniline stains are much closer to *G. cardinalis* than to *G. tristis*.

Temperature Reactions.

The majority of the grains are gelatinized at 78° to 80° C., and all at 82° to 83° C., mean 82.5° C. The temperature of gelatinization is nearer to *G. cardinalis* (mean 85°) than to *G. tristis* (mean 78.5°).

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 11 per cent of the entire number of grains and 17 per cent of the total starch in 5 minutes; in about 21 per cent of the grains and 25 per cent of the total starch in 15 minutes; in about 28 per cent of the grains and 34 per cent of the total starch in 30 minutes; in about 39 per cent of the grains and 43 per cent of the total starch in 45 minutes; in about 40 per cent of the grains and 44 per cent of the total starch in 60 minutes. (Chart D 463.)

The hilum becomes very prominent and usually a small bubble is formed there, and two lines extend from the hilum to the distal corners as in *G. cardinalis*. The lamellæ, however, become distinct only on some of the grains as in *G. tristis*. Gelatinization begins and proceeds as in *G. cardinalis*, with the exception of a few grains in which gelatinization begins all around the margin as in *G. tristis*. The gelatinized grains are large and somewhat distorted but still retain some of the original form of the grain.

The process of gelatinization is qualitatively closer to *G. cardinalis*, except in a few grains in which it is closer to *G. tristis*.

The reaction with *chromic acid* begins in a few grains in 1 minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 12 per cent of the grains and 30 per cent of the total starch in 15 minutes; in about 32 per cent of the grains and 82 per cent of the total starch in 30 minutes; in about 38 per cent of the grains and 93 per cent of the total starch in 45 minutes; in about 65 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 464.)

The reaction with *pyrogallic acid* begins in rare grains in half a minute. Complete gelatinization occurs in about 1 per cent of the grains and 2 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 6 per cent of the total starch in 30 minutes; in about 6 per cent of the grains and 8 per cent of the total starch in 45 minutes; slight advance (about 6.5 per cent) of the grains and about 10 per cent of the total starch in 60 minutes. (Chart D 465.)

The reaction with *nitric acid* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 4 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 6 per cent of the total starch in 30 minutes; in about 3 per cent of the grains and 7 per cent of the total starch in 45 minutes; in about the same percentage of both the grains and total starch in 60 minutes. (Chart D 466.)

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 37 per cent of the entire number of grains and 60 per cent of the total starch in 5 minutes; in about 67 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 94 per cent of the grains and over 99 per cent of the total starch in 30 minutes; in but parts of very rare grains (over 99 per cent) of both the grains and total starch in 45 minutes. (Chart D 467.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 9 per cent of the total starch in 5 minutes; in about 12 per cent of the grains and 15 per cent of the total starch in 15 minutes; in about 18 per cent of the grains and 24 per cent of the total starch in 30 minutes; in about 23 per cent of the grains and 35 per cent of the total starch in 15 minutes; in about 26 per cent of the grains and 42 per cent of the total starch in 60 minutes. (Chart D 468.)

Gelatinization begins and proceeds as in both parents, but the distention and folding of the capsule at the margin is much less frequently observed. If the grains are attacked at the margin, a clear narrow border, which is not folded and frequently remains throughout the reaction, is generally observed instead of the great distention commonly noted for the parents. There is much greater variation in the progress of the reaction among the different grains than noted in either parent. A larger percentage of grains (chiefly the medium-sized and smaller grains resembling those of *G. tristis*) are completely gelatinized than in *G. cardinalis,* but many more grains among the globular and compound grains are much less gelatinized than in *G. cardinalis,* and thus the percentage of total starch gelatinized is less than in that species. The grains at the end of the experiment are swollen, and those similar in character to both parents are present, the grains in process of disintegration being very few, as noted for *G. cardinalis.* The reactions are, on the whole, more closely related to those of *G. cardinalis.*

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 8 per cent of the total starch in 5 minutes; in about 6 per cent of the entire number of grains and 12 per cent of the total starch in 15 minutes; in about 7 per cent of the entire number of grains and 15 per cent of the total starch in 30 minutes; in about 12 per cent of the entire number of grains and 17 per cent of the total starch in 15 minutes; in about 16 per cent of the grains and 19 per cent of the total starch in 60 minutes. (Chart D 469.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in about 9 per cent of the grains and 11 per cent of the total starch in 15 minutes; in about 11 per cent of the grains and 13 per cent of the total starch in 30 minutes; in about 13 per cent of the grains and 17 per cent of the total starch in 45 minutes; in about 15 per cent of the grains and 20 per cent of the total starch in 60 minutes. (Chart D 470.)

The hilum is not so distinct as in *G. cardinalis,* the same as in *G. tristis.* The lamellæ are somewhat indistinct as in *G. cardinalis.* Gelatinization begins at the hilum and the process is the same as in *G. cardinalis,* except that there are more grains completely gelatinized, though not so many as in *G. tristis.* In this reaction *G. colvillei* is qualitatively closer to *G. cardinalis* than to *G. tristis.*

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 2 per cent of the grains and 9 per cent of the total starch in 5 minutes; in about 8 per cent of the grains and 15 per cent of the total starch in 15 minutes; in about 12 per cent of the grains and 18 per cent of the starch in 30 minutes; in about 18 per cent of the grains and 25 per cent of the total starch in 45 minutes; in about 21 per cent of the grains and 27 per cent of the total starch in 60 minutes. (Chart D 471.)

The reaction with *potassium sulphide* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 15 minutes; slight advance in 30 minutes; in about 3 per cent of the grains and 4 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 472.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 9 per cent of the total starch in 5 minutes; in about 10 per cent of the grains and 15 per cent of the total starch in 15 minutes;

in about 14 per cent of the grains and 20 per cent of the total starch in 30 minutes; in about 16 per cent of the grains and 22 per cent of the total starch in 45 minutes; in about 20 per cent of the grains and 28 per cent of the total starch in 60 minutes. (Chart D 473.)

The hilum becomes prominent as in *G. cardinalis.* The lamellæ appear only after gelatinization has proceeded for some distance. Gelatinization begins at the hilum and proceeds in all respects as described under *G. cardinalis.* The grains, however, are somewhat more resistant and gelatinize less rapidly than in that starch. The gelatinized grains are rather thick-walled and moderately large, but somewhat distorted, and retain some of the form of the untreated grain as in *G. cardinalis.* In this reaction *G. colvillei* is closer qualitatively to *G. cardinalis* than to *G. tristis.*

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 9 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 12 per cent of the total starch in 30 minutes; in about 7 per cent of the grains and 15 per cent of the total starch in 45 minutes; in about 9 per cent of the grains and 17 per cent of the total starch in 60 minutes. (Chart D 474.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 20 per cent of the entire number of grains and 23 per cent of the total starch in 5 minutes; in about 58 per cent of the grains and 59 per cent of the total starch in 15 minutes; in about 79 per cent of the grains and 80 per cent of the total starch in 30 minutes; in about 90 per cent of the grains and total starch in 45 minutes; in about 97 per cent of the grains and total starch in 60 minutes. (Chart D 475.)

The hilum becomes distinct and a bubble is often formed there, quite as often as in *G. cardinalis.* The lamellæ are not visible. Gelatinization begins at the hilum in the smaller and less resistant grains and also in most of the more resistant grains; in the others at the corners of the distal pressure facets. In this way it shows more resemblance to *G. cardinalis* than to *G. tristis.* The progress of gelatinization in each of the three types of grains is the same as that described under the parents. The gelatinized grains are large and somewhat distorted, but retain much of their original form. There are no differences to be noted between the gelatinized grains of the hybrid and of the two parents. In this reaction *G. colvillei* is qualitatively closer in the majority of the grains to *G. cardinalis,* though in a few grains it is closer to *G. tristis.*

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in the same percentage of the grains and 5 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 6 per cent of the total starch in 30 minutes; little if any further change in 45 and 60 minutes. (Chart D 476.)

The reaction with *uronium ntirate* begins in rare grains immediately. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about the same percentage of the grains and 2 per cent of the total starch in 15 minutes; in about 1 per cent of the grains and 3 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 4 per cent of the total starch in 45 minutes; in about the same percentage of both the grains and total starch in 60 minutes. (Chart D 477.)

The reaction with *strontium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about the same percentage of the grains and 5 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 8 per cent of the total starch in 30 minutes; in about 10 per cent of the grains and 16 per cent of the total starch in 45 minutes; in about 16 per cent of the grains and 21 per cent of the total starch in 60 minutes. (Chart D 478.)

The reaction with *cobalt nitrate* begins immediately in a few smaller grains and in rare larger grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 2.5 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes. (Chart D 479.)

The smaller grains are quickly gelatinized as in the parents; not more than about 0.5 per cent of the larger grains are gelatinized at the end of 60 minutes, as noted for *G. cardinalis.*

The reaction with *copper nitrate* begins in rare grains immediately. Complete gelatinization occurs in about 1 per cent of the grains and 2 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 15 minutes; in about the same percentage of the grains and a slight advance in the total starch in 30 minutes; in about the same percentage of the grains and 4 per cent of the total starch in 45 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 60 minutes. (Chart D 480.)

The reaction with *cupric chloride* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about the same percentage of both the grains and total starch in 30 minutes; in about 5 per cent of the grains and 6 per cent of the total starch in 45 minutes; in about the same percentage of both the grains and total starch in 60 minutes. (Chart D 481.)

The reaction with *barium chloride* begins in a few of the smaller grains immediately. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; very little if any advance in 30 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 45 minutes; little if any advance in 60 minutes. (Chart D 482.) A few of the smaller grains and an occasional medium-sized grain are

gelatinized, but the larger grains are little if at all affected by the reagent.

The reaction with *mercuric chloride* begins in a few of the smaller grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 4 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 5 per cent of the total starch in 30 minutes; little if any advance is observed in 45 and 60 minutes. (Chart D 483.) Only the smaller grains and rare medium-sized grains are gelatinized.

10. TRITONIA.

This genus includes over 30 species of South African bulbous plants, only a few of which are in cultivation. The older generic name is *Montbretia,* and tritonias are commonly known by this name. The genus is closely related to *Gladiolus,* and some of the species have been classified with the latter, as, for instance, *T. lineata* Ker-Gawl as *G. lineatus,* and *T. securigera* Ker-Gawl as *G. securiger.*

Starches of the following parent-stocks and hybrid-stocks were studied:

35. *T. pottsii* Benth. (*Montbretia pottsii* Baker) (seed parent), *T. crocosmia aurea* Planch (pollen parent), and *T. crocosmæflora* Lemoine (hybrid).

The specimens were obtained from E. H. Krelage and Son, Haarlem, Holland.

35. Starches of Tritonia pottsii, T. crocosmia aurea, and T. crocosmæflora.

Tritonia pottsii (Seed Parent).

(Plate 20, fig. 118; Charts D 484 to D 504.)

Histologic Properties.

In *form* the majority of the grains are simple and the separated components of aggregates, with the exception of a few which either still remain in small aggregates or which are permanently isolated grains. Rare compound grains composed of 2 components are observed. Well-defined pressure facets are present on the majority of grains. The grains are generally regular, but sometimes irregular, and the irregularities are due to the following causes: (1) A small elevation located near the distal margin; (2) the longitudinal axis may be slightly shifted; (3) a small, concave depression, probably a pressure facet, may be present at indefinite points on the curved surface of a grain. The conspicuous forms of the separated component grains are dome-shaped with squared, pointed, or diagonal distal margin, ovoid with squared or pointed distal margin, high bell-jar shaped, sugar-loaf, polygonal, and nearly round with a concave depression. The conspicuous forms of the permanently isolated grains are nearly round, ovoid, ellipsoidal, round, and broad triangular with rounded angles. The aggregates usually consist of from 2 to 4 components of equal or nearly equal size which are compactly arranged. Occasionally they differ considerably in size, consisting, as a rule, of 1 large and 1 small, or 1 large with 2 fair-sized components, fitted compactly at the distal margin. The grains are not flattened.

The *hilum* is a small, slightly refractive, round or lenticular-shaped spot, which is usually single and, rarely, may be double. A small rounded cavity is sometimes located at the hilum. The hilum is not usually fissured, but occasionally small clefts are found which have the following forms: (1) A single, straight or slightly curved diagonal or transverse line; (2) two are arranged as soaring-bird figure; (3) two or three fissures often extend obliquely from the hilum to the distal corners of dome-shaped grains with squared or pointed base. The hilum is either centric in position, or the range of eccentricity is from 0.45 to 0.35, more often about 0.4, of the longitudinal axis.

The *lamellæ* are not usually distinct. Most of them are demonstrable and are fine to moderately fine, sometimes one located at varying distances from the hilum is coarser, more distinct, and slightly refractive. Those directly around the hilum may form circular rings, but a very short distance outward they tend to follow the outline of the grain. A marginal band in which the lamellæ are usually indistinct is sometimes present. On the large, rounded, permanently isolated grains the number is occasionally found to be 14 to 18, and on the separated dome-shaped grains 11 to 12.

The *size* of the grains varies from the smaller which are 4 by 3μ, to the larger nearly round permanently isolated grains which are 34 by 32μ, and larger dome-shaped separated components which are 28 by 28μ, in length and breadth. The common size of the permanently isolated grains is about 22 by 20μ, and of the dome-shaped separated grains about 20 by 22μ in length aud breadth.

Polariscopic Properties.

The *figure* is usually centric to slightly eccentric, but is quite eccentric in a few grains; and is generally distinct and clean-cut. The lines are moderately fine and intersect both at right and oblique angles. They are straight with broadening towards the margin in the majority of the grains; but are moderately often bent and occasionally bisected. Both double and multiple figures are observed.

The *degree of polarization* is high (value 70). It varies in the different grains from moderate to very high. There is also considerable variation in the same aspect of a grain, sometimes one quadrant being quite low.

With *selenite* the quadrants are usually well defined, generally slightly unequal, and sometimes irregular. The blue is generally pure, but the yellow is frequently not pure throughout the entire quadrant.

Iodine Reactions.

With 0.25 per cent Lugol's solution, the grains do not color at all with the exception of a few scattered ones which immediately become a moderate dull blue-violet, which deepens somewhat rapidly (value 10). With 0.125 per cent Lugol's solution the grains do not color at first, nor do they take on the least color for some time. After heating in water until all the grains are gelatinized and then adding 2 per cent Lugol's solution, the *grains* color a light to moderately deep indigo-blue, some with reddish tint, and the *solution* becomes moderately deep indigo-blue. If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent

Lugol's solution, the *grain-residues* become a very deep blue, many with a reddish tint; most of the *capsules* color a wine-red, with a few deep heliotrope; and the *solution* becomes a deep indigo-blue.

Aniline Reactions.

With *gentian violet* the grains stain lightly at once, and in half an hour they are light to moderate (value 40) in color.

With *safranin* the grains color lightly at once, and in half an hour they are light to moderate (value 40) in color.

Temperature Reactions.

The majority of the grains are gelatinized at 73° to 75° C., and all at 76° to 77.5° C., mean 76.7° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 7 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 22 per cent of the grains and 26 per cent of the total starch in 15 minutes; in about 44 per cent of the grains and 48 per cent of the total starch in 30 minutes; in about 52 per cent of the grains and 60 per cent of the total starch in 45 minutes; in about 60 per cent of the grains and 63 per cent of the total starch in 60 minutes. (Chart D 484.)

The hilum becomes very prominent and a bubble is frequently formed there. No lamellæ are visible. A refractive band is slowly formed around the margin of some of the grains, but never appears in all. Gelatinization begins at the distal end in those grains in which the hilum is eccentric, in others at some point on the margin, and in a few all around the margin. It is preceded in every case by a deep pitting of the surface. As gelatinization progresses the ungelatinized starch is invaded by fissures, and masses are broken off and then gelatinized, finally the hilum is reached; the bubble if present shrinks and disappears, but the hilum itself is not observed to swell, and the portion at the proximal end finally is gelatinized. Because of the fact that the proximal starch is the last to gelatinize we often find an apparent invagination at the proximal end of the gelatinized grains, otherwise though considerably enlarged they retain much of their original form. About two-fifths of the total number of grains are not gelatinized at the end of 1 hour.

The reaction with *chromic acid* begins in a few grains in half a minute. Complete gelatinization occurs in about 1 per cent of the grains and 5 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 50 per cent of the total starch in 15 minutes; in about 50 per cent of the grains and 98 per cent of the total starch in 30 minutes; in about 65 per cent of the grains and 99 per cent of the total starch in 45 minutes; in about 95 per cent of the grains and over 99 per cent of the total starch in 60 minutes. (Chart D 485.)

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 13 per cent of the total starch in 5 minutes; in about 28 per cent of the grains and 54 per cent of the total starch in 15 minutes; in about 34 per cent of the grains and 78 per cent of the total starch in 30 minutes; in about 43 per cent of the grains and 91 per cent of the total starch in 45 minutes; in about 51 per cent of the grains and 96 per cent of the total starch in 60 minutes. (Chart D 486.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 14 per cent of the grains and 25 per cent of the total starch in 15 minutes; in about 30 per cent of the grains and 47 per cent of the total starch in 30 minutes; very slight progress in 45 minutes; in about 33 per cent of the grains and 50 per cent of the total starch in 60 minutes. (Chart D 487.)

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 90 per cent of the entire number of grains and 99 per cent of the total starch in 5 minutes; complete gelatinization of all grains (100 per cent both of the grains and total starch) occurs in 10 minutes. (Chart D 488.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 37 per cent of the entire number of grains and 80 per cent of the total starch in 5 minutes; in about 63 per cent of the grains and 92 per cent of the total starch in 15 minutes; in about 68 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 82 per cent of the grains and 97 per cent of the total starch in 45 minutes; in about 85 per cent of the grains and 99 per cent of the total starch in 60 minutes. (Chart D 489.)

The hilum becomes very distinct and two canals or fissures are projected from the hilum to the distal corners of the pressure facets. The lamellæ are not visible. Gelatinization is often preceded by a pitted appearance of the surface at the margin, and occasionally over the whole grain. Gelatinization begins at the hilum, and in most of the grains (almost immediately afterwards) at a point on the margin, or in those grains with pressure facets at the corners of the pressure facets. The initial enlargement of the hilum is followed by the appearance of fine striæ radiating to the margin in every direction, except in the one segment between the hilum and the point on the margin which is gelatinized—here all the starch is gelatinized. The fine striæ divide the substance of the grain into spicules, and as gelatinization proceeds granules are broken off the ends of these until the interior of the grain is filled with fine granules. The remainder of the starch forms a broad striated band at the margin, around the inner border of this is a row of rather coarse granules, these and the finer granules in the interior of the grain are gelatinized and the striated margin is broken up into coarse granules which finally are also gelatinized. The capsule in the meantime is sometimes, but not often, dissolved at several points, and the separated pieces of the margin float off and are gelatinized separately. The gelatinized grains which remain intact are large and considerably distorted, but retain some of the form of the untreated grain.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 9 per cent of the total starch in 5 minutes; in about 5 per cent of the entire number of grains and 15 per cent of the total starch in 15 minutes; in about 15 per cent of the entire number of grains and 28 per cent of the total starch in 30 minutes; in about 20 per cent of the grains and 33

per cent of the total starch in 45 minutes; in about 28 per cent of the grains and 39 per cent of the total starch in 60 minutes. (Chart D 490.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 15 per cent of the total starch in 5 minutes; in about 12 per cent of the grains and 29 per cent of the total starch in 15 minutes; in about 16 per cent of the grains and 45 per cent of the total starch in 30 minutes; in about 42 per cent of the grains and 62 per cent of the total starch in 45 minutes; in about 50 per cent of the grains and 67 per cent of the total starch in 60 minutes. (Chart D 491.)

The hilum becomes moderately distinct, and the lamellæ are not visible. Gelatinization begins at the hilum, and after the initial enlargement, fine striæ appear, radiating from the hilum to the margin. The hilum and the grain continue to swell, and the more resistant material is gathered at the margin in a striated band, which, however, rapidly becomes thinner and more nearly transparent. In some grains gelatinization begins simultaneously at the hilum and at a point on the margin, and a segment of the grain from the hilum to the margin is rapidly gelatinized and the rest less rapidly. The process is the same as already described. The gelatinized grains are large and somewhat distorted but retain some of the form of the untreated grain.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 50 per cent of the entire number of grains and 78 per cent of the total starch in 5 minutes; in about 60 per cent of the grains and 85 per cent of the total starch in 15 minutes; in about 75 per cent of the grains and 93 per cent of the total starch in 30 minutes; in about 80 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about the same percentage of grains and 97 per cent of the total starch in 60 minutes. (Chart D 492.)

The reaction with *potassium sulphide* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 7 per cent of the total starch in 15 minutes; slight advance in 30 minutes; in about 3 per cent of the grains and 8 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 493.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 29 per cent of the entire number of grains and 62 per cent of the total starch in 5 minutes; in about 44 per cent of the grains and 77 per cent of the total starch in 15 minutes; in about 55 per cent of the grains and 81 per cent of the total starch in 30 minutes; in about 59 per cent of the grains and 84 per cent of the total starch in 45 minutes; in about 67 per cent of the grains and 87 per cent of the total starch in 60 minutes. (Chart D 494.)

The hilum becomes very distinct and, if a pressure facet is present, two fissures or canals may be seen to extend from the hilum to the distal corners of the pressure facet. The lamellæ are not visible, probably due to the masses of foreign matter which cling to the grains in this preparation. Gelatinization, which is often preceded by a pitted appearance, begins either at the hilum alone, or at the hilum and one point on the margin simultaneously. The starch between these two points is rapidly gelatinized, and the remaining portion becomes divided into fine spicules by striæ radiating from the hilum, the starch nearest the hilum is now broken up into rather fine granules which separate one from another and gelatinize, finally there remains a very much swollen grain, one segment of which is completely gelatinized, and the rest has at the margin a thick, finely striated band, inside of which is a number of granules. This band becomes gradually thinner and more transparent until complete gelatinization of the whole grain has occurred; some granules, however, persist for a long time in the interior of the grain. The gelatinized grains are moderately large and somewhat distorted, but show much of the form of the untreated grain.

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 14 per cent of the entire number of grains and 25 per cent of the total starch in 5 minutes; in about 25 per cent of the grains and 34 per cent of the total starch in 15 minutes; in about 31 per cent of the grains and 54 per cent of the total starch in 30 minutes; in about 41 per cent of the grains and 62 per cent of the total starch in 45 minutes; in about 59 per cent of the grains and 68 per cent of the total starch in 60 minutes. (Chart D 495.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 56 per cent of the entire number of grains and 65 per cent of the total starch in 5 minutes; in about 88 per cent of the grains and 92 per cent of the total starch in 15 minutes; in about 98 per cent of the grains and over 99 per cent of the total starch in 30 minutes. (Chart D 496.)

The hilum becomes distinct, and a bubble is often formed there. The lamellæ are not visible. Gelatinization is preceded by a pitted appearance of the starch at the distal end or, if the hilum is centric, of the portion all around the margin. After the marginal starch has gelatinized at various points, the remaining inner part becomes invaded by small cracks into which the reagent evidently penetrates, gelatinization of the starch between these cracks ensuing in each case. When the hilum is reached, it enlarges suddenly, and the bubble, if present, swells, shrinks, and finally disappears. The proximal starch is gelatinized, and finally a small portion just distal to the hilum. The gelatinized grains are moderately large and somewhat distorted, but retain some of their original form. After one hour about 0.2 per cent of the grains are not gelatinized.

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 15 per cent of the total starch in 5 minutes; in about 10 per cent of the grains and 19 per cent of the total starch in 15 minutes; in about 12 per cent of the grains and 22 per cent of the total starch in 30 minutes; in about 20 per cent of the entire number of grains and 26 per cent of the total starch in 45 minutes; in about 28 per cent of the grains and 36 per cent of the total starch in 60 minutes. (Chart D 497.)

The reaction with *uranium nitrate* begins immediately. Complete gelatinization occurs in about 3 per

cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 9 per cent of the total starch in 15 minutes; in about 9 per cent of the grains and 13 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 16 per cent of the total starch in 45 minutes; in about the same percentage of the grains and total starch in 60 minutes. (Chart D 498.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 8 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 18 per cent of the grains and 24 per cent of the total starch in 15 minutes; in about 26 per cent of the grains and 38 per cent of the total starch in 30 minutes; in about 29 per cent of the grains and 41 per cent of the total starch in 45 minutes; in about 38 per cent of the grains and 50 per cent of the total starch in 60 minutes. (Chart D 499.)

The reaction with *cobalt nitrate* begins immediately. Complete gelatinization occurs in about 3 per cent of the grains and 7 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 11 per cent of the total starch in 15 minutes; in about 7 per cent of the grains and 15 per cent of the total starch in 30 minutes; in about the same percentage of both the grains and total starch in 45 and 60 minutes, respectively. (Chart D 500.)

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 5 per cent of the grains and 11 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 20 per cent of the total starch in 15 minutes; in about the same percentage of the grains and slight advance in the total starch (about 24 per cent) in 30 minutes; in about 10 per cent of the grains and 28 per cent of the total starch in 45 minutes; in about 13 per cent of the grains and 31 per cent of the total starch in 60 minutes. (Chart D 501.)

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 7 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 9 per cent of the grains and 14 per cent of the total starch in 15 minutes; in about 10 per cent of the grains and 16 per cent of the total starch in 30 minutes; in about the same percentage of both the grains and total starch in 60 minutes. (Chart D 502.)

The reaction with *barium chloride* begins in a very few grains immediately. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; very slight advance in 15 minutes; in about 1 per cent of the grains and 3 per cent of the total starch in 30 minutes; very slight if any advance occurs in 45 and 60 minutes, respectively. (Chart D 503.)

The reaction with *mercuric chloride* begins in a few grains immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 9 per cent of the total starch in 15 minutes; in about the same percentage of the grains and 12 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 13 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 15 per cent of the total starch in 60 minutes. (Chart D 504.)

Tritonia crocosmia aurea (Pollen Parent).

(Plate 20, fig. 119; Charts D 484 to D 504.)

Histologic Properties.

In *form* the majority of the grains are simple and are the separated components of aggregates, with the exception of a few which either remain in small aggregates or those which are permanently isolated grains; the proportion of the last named is considerably larger than in *T. pottsii.* Compound grains of 2 components are occasionally observed; they are more numerous than in *T. pottsii.* Well-defined pressure facets are present in the majority of grains, but not so numerous as in *T. pottsii.* The surface of the grains is usually regular, which is found in a few more grains than in *T. pottsii,* although the same irregularities may occur; and in addition reticular markings are occasionally found on the large grains, which probably are the result of pressure of small grains. While such markings were not noted in *T. pottsii,* yet they may be obscured by the foreign material that often incrusts the larger grains of the specimen studied. The conspicuous forms of the separated component grains are the same as in *T. pottsii,* but the ovoid form with squared or pointed end, the nearly round with concave depression, and the high bell-jar shaped, are more numerous than in *T. pottsii.* The conspicuous form of the permanently isolated grains are the same as in *T. pottsii,* but more of the ovoid and the triangular forms are found, the latter being more elongated than in *T. pottsii.* The aggregates usually consist of from 2 to 4 components which may be of about equal size and compactly arranged, as is generally found in *T. pottsii;* but more frequently they consist of 1 small component adhering to the surface of 1 large component; the latter are much more numerous than in *T. pottsii.* The grains, as in *T. pottsii,* are not flattened.

The *hilum* is a small, round or lenticular spot, which is more refractive than in *T. pottsii.* It is usually single, but rarely double, as in *T. pottsii.* A small, rounded or irregular cavity is found more frequently at the hilum than in *T. pottsii.* The hilum is frequently fissured, much more often than in *T. pottsii,* and the clefts are, as a rule, deeper. The structure of the clefts is the same as that noted for *T. pottsii,* with the addition of dragon-fly, cruciate, and T-shaped figures. Fissures extending distalward from the hilum are observed, the same as found in *T. pottsii,* with addition of an occasional single, longitudinal fissure found in ovoid grains. The hilum is either centric or is eccentric from 0.45 to 0.25, commonly 0.35, of the longitudinal axis.

The *lamellæ* are usually not distinct, and are demonstrable throughout the grain in somewhat fewer grains than in *T. pottsii.* Most of them are fine to moderately fine; when demonstrable, often one is located at varying distances from the hilum, and is more distinct, coarser, and slightly refractive, this being observed in a larger proportion of grains than in *T. pottsii.* The lamellæ around the hilum may form circular rings, but a short distance outward tend to follow the outline of the grain, as in *T. pottsii.* A marginal band in which the lamellæ are refractive and usually very indistinct is observed

quite often, and more frequently than in *T. pottsii*. On the large permanently isolated grains 14 to 16 may be counted; and on the larger separated grains, usually 12.

The *size* of the grains varies from the smaller which are 3 by 2μ, to the larger permanently isolated ovoid grains which are 34 by 28μ, and the separated components which are 26 by 20μ, in length and breadth. The common size of permanently isolated grains is 25 by 18μ, and of separated grains 20 by 17μ, in length and breadth.

Polariscopic Properties.

The *figure* is usually centric to slightly eccentric, but sometimes quite eccentric; and there are more grains in which the figure is quite eccentric than in *T. pottsii*. Both the character of the lines and their intersection are similar to that of *T. pottsii*, but they are much less often bent than in *T. pottsii*, while bisection is not observed, although occasionally present in *T. pottsii*. Both double and multiple figures are observed as in *T. pottsii*.

The *degree of polarization* is high (value 75). The variation in the different grains is from high to very high, with fewer of the latter than in *T. pottsii*. There is much less variation in the different grains, as well as in the same aspect of a given grain, than in *T. pottsii*.

With *selenite* the quadrants are somewhat more clean-cut and more regular than in *T. pottsii*. They are generally slightly unequal in size, as in *T. pottsii*. The colors are generally pure, more often pure than in *T. pottsii*.

Iodine Reactions.

With 0.25 per cent Lugol's solution, the grains immediately color a moderate blue-violet (value 50), which deepens rapidly, becoming more bluish in tint; they are a little brighter, deeper, and more bluish, and deepen more rapidly than the few scattered grains of *T. pottsii*, which show any color with this reagent. With 0.125 per cent Lugol's solution, the grains color a light blue-violet, which becomes bluer as it quickly deepens. After heating in water until all the grains are gelatinized and then adding 2 per cent Lugol's solution most of the grains become a moderate blue, a few having a moderately deep blue color, none with reddish tint; and the *solution* colors a deep indigo-blue. There is much less variation among the different grains, with fewer of the moderately deep blue color, hence the mean is of the same depth, but less reddish in tint than in *T. pottsii*, and the solution is a little deeper in color. If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* are moderately deep to very deep blue in color, some with reddish tint; they are not quite so deep, nor so reddish in tint, as in *T. pottsii;* the *solution* becomes a very deep indigo-blue, slightly deeper than in *T. pottsii*. The *capsules* vary from a light to a deep heliotrope color, the mean is lighter in color and less reddish in tint than in *T. pottsii*.

Aniline Reactions.

With *gentian violet* the grains stain lightly at once, and in half an hour they are light to moderate in color (value 35), with more of the former than in *T. pottsii;* hence the mean is somewhat lighter.

With *safranin* the grains stain lightly at once, and in half an hour they are light to moderate in color (value 35), with more of the former than in *T. pottsii;* hence the mean is somewhat lighter.

Temperature Reactions.

The majority of the grains are gelatinized at 78° to 80° C., and all at 80° to 82° C., mean 81° C., or 4.3° higher than in *T. pottsii*.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 10 per cent of the entire number of grains and 15 per cent of the total starch in 5 minutes; in about 37 per cent of the grains and 40 per cent of the total starch in 15 minutes; in about 50 per cent of the grains and 52 per cent of the total starch in 30 minutes; in about 58 per cent of the grains and 62 per cent of total starch in 45 minutes; in about 60 per cent of the grains and 66 per cent of the total starch in 60 minutes. (Chart D 484.)

The hilum becomes very prominent, and a bubble is nearly always formed there. The lamellæ are not visible. A broad, refractive band forms very slowly, but may be seen around the margin of most of the grains. Gelatinization begins, usually, at the distal margin preceded by a pitted appearance on the distal surface. In some of the small grains gelatinization begins at the hilum. Gelatinization progresses slowly from the distal margin toward the proximal end, the ungelatinized starch, however, not being invaded by fissures, as in *T. pottsii*, although the more resistant portion at the proximal end is sometimes split into 2 or 3 pieces. In the smaller grains little can be made out of the process except that the hilum swells and pushes the ungelatinized starch to the margin where it remains until gelatinized. The gelatinized grains are large and not much distorted.

The reaction with *chromic acid* begins in a few grains in half a minute. Complete gelatinization occurs in but few grains, less than 0.5 per cent of the entire number and 2 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 24 per cent of the total starch in 15 minutes; in about 13 per cent of the grains and 54 per cent of the total starch in 30 minutes; in about 30 per cent of the grains and 80 per cent of the total starch in 45 minutes; in about 35 per cent of the grains and 90 per cent of the total starch in 60 minutes. (Chart D 485.)

The reaction with *pyrogallic acid* begins in a few grains in half a minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 9 per cent of the total starch in 15 minutes; in about 12 per cent of the grains and 20 per cent of the total starch in 30 minutes; in about 15 per cent of the grains and 40 per cent of the total starch in 45 minutes; in about 20 per cent of the grains and 50 per cent of the total starch in 60 minutes. (Chart D 486.)

The reaction with *nitric acid* begins in a few grains immediately. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 9 per cent of the total starch in 30 minutes; in about 5 per cent of the grains and 12 per cent of the total starch in 45 minutes; about the same percentage of both the grains and total starch in 60 minutes. (Chart D 487.)

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 78 per cent of the entire number of grains and 95 per cent of the total starch in 5 minutes; in about 92 per cent of the grains and 99 per cent of the total starch in 10 minutes; in about 96 per cent of the grains and over 99 per cent of the total starch in 15 minutes. (Chart D 488.)

The reaction with *hydrochloric* acid begins immediately. Complete gelatinization occurs in about 32 per cent of the entire number of grains and 51 per cent of the total starch in 5 minuntes; in about 44 per cent of the grains and 73 per cent of the total starch in 15 minutes; in about 62 per cent of the grains and 86 per cent of the total starch in 30 minutes; in about 69 per cent of the grains and 90 per cent of the total starch in 45 minutes; in about 73 per cent of the grains and 92 per cent of the total starch in 60 minutes. (Chart D 489.)

The hilum becomes distinct as in *T. pottsii*, and two canals or fissures extend from the hilum to the distal corners of the pressure facets when these are present. The lamellæ become visible, especially toward the distal end, but are not distinct. Gelatinization begins at the hilum, and fine striæ radiate from the hilum to the margin as in *T. pottsii*, but, differing from the process in that starch, the space between the hilum and the distal end becomes invaded by coarse irregular fissures and broken up into coarse granules, and these begin to gelatinize; then as the hilum enlarges a number of irregular fissures invade the remainder of the starch at the sides and at the proximal end. The inner portion thus invaded soon gelatinizes, leaving some scattered granules, and a striated lamellated marginal band is formed; this band and the granules in the interior are more distinct than in *T. pottsii*. Before gelatinization is complete the margin is dissolved in one or more places, and granules are broken off the ungelatinized portion and float away, until all the material is dissolved. There are few if any completely gelatinized grains, which is different from *T. pottsii.*

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 9 per cent of the total starch in 30 minutes; in about 5 per cent of the grains and 14 per cent of the total starch in 45 minutes; in about 7 per cent of the grains and 20 per cent of the total starch in 60 minutes. (Chart D 490.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 9 per cent of the total starch in 5 minutes; in about 5 per cent of the entire number of grains and 12 per cent of the total starch in 15 minutes; in about 11 per cent of the entire number of grains and 18 per cent of the total starch in 30 minutes; in about 16 per cent of the grains and 22 per cent of the total starch in 45 minutes; in about 20 per cent of the grains and 27 per cent of the total starch in 60 minutes. (Chart D 491.)

The hilum becomes more distinct than in *T. pottsii*, and the lamellæ are visible but not very distinct. Gelatinization begins at the hilum as in *T. pottsii*, but never at the hilum and the margin simultaneously as in that species, but the process of gelatinization is the same except that the striæ radiating from the hilum are more distinct than in *T. pottsii*, and there is a smaller number of quickly reacting grains, very few reaching the point of complete gelatinization. The gelatinized grains are swollen and somewhat distorted, but retain more of the form of the untreated grain than do those of *T. pottsii.*

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 11 per cent of the entire number of grains and 33 per cent of the total starch in 5 minutes; in about 16 per cent of the grains and 57 per cent of the total starch in 15 minutes; in about 40 per cent of the grains and 75 per cent of the total starch in 30 minutes; in about 53 per cent of the grains and 82 per cent of the total starch in 45 minutes; in about 58 per cent of the grains and 86 per cent of the total starch in 60 minutes. (Chart D 492.)

The reaction with *potassium sulphide* begins in a few grains in half a minute. Complete gelatinization was not observed in any of the grains and in 0.5 per cent of the total starch in 5 minutes; complete gelatinization is observed in but rare grains, less than 0.5 per cent of the entire number, and 1 per cent of the total starch in 15 minutes; slight advance in the total starch in 30 minutes; still in less than 0.5 per cent of the grains and 2 per cent of the total starch in 45 minutes; about the same in 60 minutes. (Chart D 493.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 6 per cent of the grains and 16 per cent of the total starch in 5 minutes; in about 10 per cent of the grains and 33 per cent of the total starch in 15 minutes; in about 20 per cent of the grains and 50 per cent of the total starch in 30 minutes; in about 26 per cent of the grains and 56 per cent of the total starch in 45 minutes; in about 30 per cent of the grains and 58 per cent of the total starch in 60 minutes. (Chart D 494.)

The hilum becomes still more distinct than in *T. pottsii*, and in some of the grains with pressure facets on the margin 2 fissures leading from the hilum to the corners of these pressure facets are observed. The lamellæ, unlike those of *T. pottsii*, become distinct. Gelatinization begins at the hilum, and in many less grains than in *T. pottsii* at the margin and at the hilum simultaneously. The progress of gelatinization is essentially the same as in *T. pottsii*, except that the granules formed near the hilum are larger and more numerous, and the spicules into which the remaining starch is broken are not so fine as in that starch.

The gelatinized grains are considerably swollen and somewhat distorted, but retain much of the form of the untreated grain. There is no difference noted between this starch and that of *T. pottsii* in this respect.

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 13 per cent of the total starch in 15 minutes; in about 11 per cent of the grains and 22 per cent of the total starch in 30 minutes; in about 18 per cent of the grains and 27 per cent of the total starch in 45 minutes;

in about 22 per cent of the grains and 29 per cent of the total starch in 60 minutes. (Chart D 495.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 11 per cent of the entire number of grains and 20 per cent of the total starch in 5 minutes; in about 49 per cent of the grains and 60 per cent of the total starch in 15 minutes; in about 92 per cent of the grains and 95 per cent of the total starch in 30 minutes. (Chart D 496.)

The hilum becomes distinct and a bubble is often formed there. The lamellæ are not visible. Gelatinization is preceded by a pitted appearance as in *T. pottsii,* and usualty begins at the distal margin, but in some of the small grains at the hilum. Gelatinization progresses smoothly without any of the cracks or fissures noted under *T. pottsii,* and the proximal end is usually the most resistant instead of the portion immediately distal to the hilum as in *T. pottsii.* The gelatinized grains are considerably swollen, and are distorted, and do not show much resemblance to the form of the untreated grains.

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 6 per cent of the grains and 10 per cent of the total starch in 30 minutes; in about 8 per cent of the grains and 14 per cent of the total starch in 45 minutes; in about the same percentage of both the grains and total starch in 60 minutes. (Chart D 497.)

The reaction with *uranium nitrate* begins in rare grains in half a minute. Complete gelatinization was not observed in any of the grains and 1 per cent of the total starch is gelatinized in 5 minutes; complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 15 minutes; in about the same percentage of the grains and 4 per cent of the total starch in 30 minutes; in about 2 per cent of the grains and 5 per cent of the total starch in 45 minutes; in about the same percentage of both the grains and total starch in 60 minutes. (Chart D 498.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 2 per cent of the grains and 3 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 8 per cent of the total starch in 15 minutes; in about 12 per cent of the grains and 23 per cent of the total starch in 30 minutes; in about 23 per cent of the grains and 33 per cent of the total starch in 45 minutes; in about 33 per cent of the grains and 43 per cent of the total starch in 60 minutes. (Chart D 499.)

The reaction with *cobalt nitrate* begins in a few grains in half a minute. Complete gelatinization occurs in but rare grains, less than 0.5 per cent of the entire number and about 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; in the same percentage of the grains and 3 per cent of the total starch in 30 minutes; in the same percentage of the grains and 4 per cent of the total starch in 45 minutes; about the same in 60 minutes. (Chart D 500.)

The reaction with *copper nitrate* begins in rare grains immediately. Complete gelatinization occurs in about 1 per cent of the grains and 5 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 6 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 7 per cent of the total starch in 30 minutes; in about the same percentage of grains and slight advance in the total starch in 45 minutes; very slight advance in the grains and about 8 per cent of the total starch in 60 minutes. (Chart D 501.)

The reaction with *cupric chloride* begins in rare grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 6 per cent of the total starch in 30 minutes; in about 4 per cent of the grains and 7 per cent of the total starch in 45 minutes; in about 5 per cent of the grains and 8 per cent of the total starch in 60 minutes. (Chart D 502.)

The reaction with *barium chloride* begins in very rare grains in 2 minutes. Complete gelatinization was not observed in any of the grains and has begun in but few with a slight gelatinization around the hilum in 5 minutes; complete gelatinization was not observed in any grains and about 1 per cent of the total starch gelatinized in 15 minutes; very slight in any further advance in 30, 45, and 60 minutes, respectively. (Chart D 503.)

The reaction with *mercuric chloride* begins in rare grains in 1 minute. Complete gelatinization was not observed in any of the grains but in 1 per cent of the total starch in 5 minutes; in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 4 per cent of the total starch in 45 minutes; in about the same percentage of both the grains and the total starch in 60 minutes. (Chart D 504.)

Tritonia crocosmæflora (Hybrid).

(Plate 20, fig. 120; Charts D 484 to D 504.)

Histologic Properties.

In *form* the majority of the grains are simple, and are separated components of aggregates, with the exception of a few which still either remain in small aggregates or are permanently isolated grains. The proportion of the latter is about as in *T. pottsii,* but considerably smaller than in *T. crocosmia aurea.* Rare compound grains composed of 2 components are observed as frequently as in *T. pottsii,* but less frequently than in *T. crocosmia aurea.* Well-defined pressure facets are present on the majority of the grains. Since the proportion of separated grains is as large as in *T. pottsii,* the pressure facets are as frequently observed as in that species, but are more numerous than in *T. crocosmia aurea.* The surface of the grain is generally regular, in somewhat more grains than in *T. pottsii* and in approximately the same number as in *T. crocosmia aurea.* The same forms of irregularities as noted for both parents have been observed. The conspicuous forms of the separated grains are the same as in both parents, but the high bell-jar shaped and the ovoid with squared end are

somewhat more numerous than in *T. pottsii*, but not quite so frequently observed as in *T. crocosmia aurea*. The conspicuous forms of the permanently isolated grains are the same as in both parents, but more of the ovoid are found than in *T. pottsii*, and the same number as in *T. crocosmia aurea*. The small aggregates have the same structure and number of components as noted for both parents, but they more often consist of 1 large and 1 small than in *T. pottsii*, but the same as in *T. crocosmia aurea*. The grains, as in the parents, are not flattened. This starch is somewhat closer *T. crocosmia aurea* in form, although there are but slight differences to be noted between the three.

The *hilum* is a small, round or lenticular spot which is more refractive than in *T. pottsii*, and the same as in *T. crocosmia aurea*. Double hila are rarely observed, as in both parents. A small, rounded cavity is more frequently observed than in *T. pottsii* and as frequently as in *T. crocosmia aurea*. The hilum is frequently fissured, more often than in *T. pottsii*, and as frequently as in *T. crocosmia aurea*. The structure of the fissures is similar to those of both parents, being much more varied and deeper than in *T. pottsii*, and as prominent as in *T. crocosmia aurea*. Fissures extending distalward from the hilum are more numerous, but of similar structure to those of both parents. The hilum is either centric or eccentric from 0.45 to 0.3, commonly about 0.4, of the longitudinal axis. In eccentricity of the hilum, *T. crocosmæflora* is nearer *T. pottsii*, but in every other characteristic it is nearer *T. crocosmia aurea*.

The *lamellæ* are not usually distinct, but are demonstrable throughout the entire grain as often as in *T. pottsii*, and somewhat more often than in *T. crocosmia aurea*. The structure and the arrangement are the same as noted for both parents, but the single coarse lamella and the marginal band are more prominent than in *T. pottsii*, but not as markedly so as in *T. crocosmia aurea*. The number on the larger permanently isolated grains may be from 16 to 18, and on the larger separated grains usually 12. In the character of the lamellæ *T. crocosmæflora* is somewhat nearer to *T. pottsii*, although there are very few and minor differences to be noted between the grains of the three starches.

The *size* of the grains varies from the smaller which are 3 by 2μ, to the larger permanently isolated grains which are 32 by 27μ, and the larger dome-shaped separated components which are 28 by 22μ, in length and breadth. The common size of the permanently isolated grains is about 22 by 20μ and of the separated about 20 by 20μ, in length and breadth. In size *T. crocosmæflora* is nearer to *T. pottsii* than to *T. crocosmia aurea*.

Polariscopic Properties.

The *figure* is usually centric to slightly eccentric, but is quite eccentric in somewhat more grains than in *T. pottsii*, but in fewer than in *T. crocosmia aurea*. The lines are moderately fine and also intersect as in both parents; while they are straight with broadening towards the margin in the majority of the grains, yet they are moderately often bent and occasionally bisected as in *T. pottsii*, but more often than in *T. crocosmia aurea*. Both double and multiple figures are observed as in both parents.

The *degree of polarization* is high (value 67). The grains vary from moderate to very high, with fewer of the latter than in both parents, the mean being therefore slightly lower than in *T. pottsii;* and there is more variation in the different grains, with the mean lower than in *T. crocosmia aurea*. There is also considerable variation in the same aspect of a grain, as in *T. pottsii*, and more than in *T. crocosmia aurea*.

With *selenite* the quadrants are usually well defined, generally slightly unequal in size, and sometimes irregular, about as in *T. pottsii*, but neither quite so clean-cut nor so regular as in *T. crocosmia aurea*. The blue is generally pure, but the yellow is frequently not pure throughout the entire quadrant, the same as in *T. pottsii*, but not so pure as in *T. crocosmia aurea*.

In the degree of polarization, the character of the figure, and the reaction with selenite, *T. crocosmæflora* is closer to *T. pottsii* than to *T. crocosmia aurea*.

Iodine Reactions.

With 0.25 per cent Lugol's solution most of the grains immediately color a light reddish violet (value 25), which deepens somewhat rapidly with considerable variation in the different grains, while a few remain colorless, and with much more variation than in both parents. The color is lighter and more reddish than that of the few grains of *T. pottsii* which show any reaction with this reagent; but the mean is considerably deeper, since most of the grains remain colorless in *T. pottsii*. The color is much lighter and is more reddish than in *T. crocosmia aurea*. With 0.125 per cent Lugol's solution, most of the grains remain colorless, while a few scattered grains are a light blue-violet which quickly deepens with a more bluish tint; the majority are colorless as are a few grains of *T. pottsii*, while the scattered grains are of the same depth and tint as in *T. crocosmia aurea*. After heating in water until all the grains are gelatinized and then adding a 2 per cent Lugol's solution, the gelatinized *grains* become moderately deep blue, some with reddish tint, deeper but near the tint of *T. pottsii*, and deeper and more reddish in tint than in *T. crocosmia aurea*. The *solution* becomes a deep indigo-blue, somewhat deeper than in *T. pottsii*, and as deep as in *T. crocosmia aurea*. If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* become a moderate to deep blue, many with reddish tint, not so deep as in either parent, but as red as in *T. pottsii* and redder than in *T. crocosmia aurea*. The *capsules* color a deep heliotrope to wine-red, less of the latter coloring than in *T. pottsii*, hence the color is not quite so deep nor so reddish as in that species, but somewhat deeper and more reddish than in *T. crocosmia aurea*. Qualitatively and quantitatively the reaction with iodine shows a closer relationship to *T. pottsii* than to *T. crocosmia aurea*.

Aniline Reactions.

With *gentian violet* the grains immediately stain lightly at once and in half an hour they are light to moderately colored (value 40), the same as in *T. pottsii*, but deeper than in *T. crocosmia aurea*.

With *safranin* the grains immediately color lightly and in half an hour they are light to moderate in color (value 45), with a larger proportion of the latter than

in both parents, and consequently the mean is deeper than in either parent.

In the reactions with aniline stains, *T. crocosmæflora* is closer to *T. pottsii* than to *T. crocosmia aurea*.

Temperature Reactions.

The majority of the grains are gelatinized at 74 to 76° C., and all at 76 to 78° C., mean 77° C. The temperature of gelatinization though intermediate is very much closer to *T. pottsii* (mean 76.7°) than to *T. crocosmia aurea* (mean 81°).

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 8 per cent of the total starch in 5 minutes; in about 16 per cent of the grains and 20 per cent of the total starch in 15 minutes; in about 20 per cent of the grains and 22 per cent of the total starch in 30 minutes; in about 24 per cent of the grains and 29 per cent of the total starch in 45 minutes; in about 28 per cent of the grains and 30 per cent of the total starch in 60 minutes. (Chart D 484.)

The hilum becomes very prominent and a bubble is frequently formed there. No lamellæ are visible. A narrow, refractive band is formed slowly about the margins of some of the grains. Gelatinization usually begins at the distal margin, preceded by a pitted appearance as in the parents. In the smaller grains gelatinization begins at the hilum, and in a very few others around the entire margin. Gelatinization progresses very much as in both parents, except that the fissures which invade the ungelatinized starch are not so extensive. In the smaller grains it progresses as described under *T. crocosmia aurea*. The gelatinized grains are much swollen and more distorted than those of *T. crocosmia aurea*, and more like those of *T. pottsii*, but are less distorted in some cases.

In this reaction *T. crocosmæflora* shows a closer resemblance qualitatively to *T. crocosmia aurea* than to *T. pottsii*.

The reaction with *chromic acid* begins in a few grains in half a minute. Complete gelatinization occurs in about 1 per cent of the grains and 5 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 36 per cent of the total starch in 15 minutes; in about 38 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 49 per cent of the grains and 98 per cent of the total starch in 45 minutes; in about 94 per cent of the grains and over 99 per cent of the total starch in 60 minutes. (Chart D 485.)

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 2 per cent of the grains and 7 per cent of the total starch in 5 minutes; in about 22 per cent of the grains and 40 per cent of the total starch in 15 minutes; in about 24 per cent of the grains and 62 per cent of the total starch in 30 minutes; in about 37 per cent of the grains and 73 per cent of the total starch in 45 minutes; in about 44 per cent of the grains and 90 per cent of the total starch in 60 minutes. (Chart D 486.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 12 per cent of the total starch in 5 minutes; in about 16 per cent of the grains and 32 per cent of the total starch in 15 minutes; in about 26 per cent of the grains and 62 per cent of the total starch in 30 minutes; in about 29 per cent of the grains and 68 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 70 per cent of the total starch in 60 minutes. (Chart D 487.)

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 90 per cent of the entire number of grains and over 99 per cent of the total starch in 5 minutes; complete gelatinization (100 per cent) occurs in all grains in 10 minutes. (Chart D 488.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 38 per cent of the entire number of grains and 78 per cent of the total starch in 5 minutes; in about 71 per cent of the grains and 81 per cent of the total starch in 15 minutes; in about 73 per cent of the grains and 93 per cent of the total starch in 30 minutes; in about 78 per cent of the grains and 98 per cent of the total starch in 45 minutes; in about 80 per cent of the grains and 99 per cent of the total starch in 60 minutes. (Chart D 489.)

The hilum becomes distinct as in *T. pottsii*, and 2 canals are formed as in that starch. The lamellæ are more distinct than in *T. crocosmia aurea*; in *T. pottsii* they did not appear. Gelatinization begins at the hilum and the process closely resembles that described under both the parents, although the striæ and the interior granules are distinct as in *T. crocosmia aurea*. The capsule is also more apt to be dissolved in various places, and the separate pieces to dissolve later, than in *T. pottsii*, but not so frequently as in *T. crocosmia aurea*. The gelatinized grains are much swollen and considerably distorted, but retain some of the form of the untreated grain. In this reaction *T. crocosmæflora* shows a closer resemblance, qualitatively, to *T. crocosmia aurea* than to *T. pottsii*.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 12 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 17 per cent of the total starch in 30 minutes; in about 7 per cent of the grains and 23 per cent of the total starch in 45 minutes; in about 12 per cent of the grains and 33 per cent of the total starch in 60 minutes. (Chart D 490.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 14 per cent of the grains and 20 per cent of the total starch in 15 minutes; in about 28 per cent of the grains and 39 per cent of the total starch in 30 minutes; in about 36 per cent of the grains and 50 per cent of the total starch in 45 minutes; in about 45 per cent of the grains and 61 per cent of the total starch in 60 minutes. (Chart D 491.)

The hilum becomes as distinct as in *T. crocosmia aurea*, and the lamellæ are sometimes visible, but not so frequently as in *T. crocosmia aurea*. Gelatinization begins at the hilum and sometimes simultaneously at the hilum and at a certain point on the margin as in *T. pottsii*, but not so frequently as in that starch. The

process of gelatinization is nearly the same as in the parents. The grains are less quickly reacting than in *T. pottsii*, but more than *T. crocosmia aurea*. The gelatinized grains are large and somewhat distorted, but retain some of the form of the untreated grain. In this reaction *T. crocosmæflora* shows a closer resemblance, qualitatively, to *T. crocosmia aurea* than to *T. pottsii*. The three starches resemble one another closely.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 31 per cent of the entire number of grains and 69 per cent of the total starch in 5 minutes; in about 62 per cent of the grains and 86 per cent of the total starch in 15 minutes; in about 79 per cent of the grains and 93 per cent of the total starch in 30 minutes; in about 82 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 86 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 492.)

The reaction with *potassium sulphide* begins in a few grains immediately. Complete gelatinization occurs only in rare grains, less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; slight advance in 15 minutes; still in less than 0.5 per cent of the grains and 2 per cent of the total starch in 30 minutes; slight advance in 45 minutes; still in less than 0.5 per cent of the grains and 4 per cent of the total starch in 60 minutes. (Chart D 493.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 26 per cent of the grains and 60 per cent of the total starch in 5 minutes; in about 42 per cent of the grains and 71 per cent of the total starch in 15 minutes; in about 46 per cent of the grains and 77 per cent of the total starch in 30 minutes; in about 51 per cent of the grains and 89 per cent of the total starch in 45 minutes; in about 63 per cent of the grains and 91 per cent of the total starch in 60 minutes. (Chart D 494.)

The hilum becomes distinct as in *T. pottsii*, and the lamellæ are distinct in some grains but not in others, some resembling *T. pottsii* and others *T. crocosmia aurea*. Gelatinization begins at the hilum, and in slightly more grains at the hilum and margin simultaneously than in *T. crocosmia aurea*, but less than in *T. pottsii*. The process of gelatinization is nearly the same as in *T. crocosmia aurea*, only somewhat more rapid. The gelatinized grains are large and somewhat distorted as in both the parents. In this reaction *T. crocosmæflora* shows a closer resemblance, qualitatively, to *T. crocosmia aurea* than to *T. pottsii*.

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 16 per cent of the total starch in 5 minutes; in about 13 per cent of the grains and 29 per cent of the total starch in 15 minutes; in about 32 per cent of the grains and 42 per cent of the total starch in 30 minutes; in about 40 per cent of the grains and 60 per cent of the total starch in 45 minutes; in about 52 per cent of the grains and 65 per cent of the total starch in 60 minutes. (Chart D 495.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 50 per cent of the entire number of grains and 60 per cent of the total starch in 5 minutes; in about 92 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 97 per cent of the grains and over 99 per cent of the total starch in 30 minutes. (Chart D 496.)

The hilum becomes distinct and a bubble is often formed there. The lamellæ are not visible. Gelatinization, which is preceded by a pitted appearance as noted under the two parents, begins at the hilum in a few grains, and at the corners of the distal pressure facets in most of the grains. It progresses in the same way as noted in *T. crocosmia aurea*. The gelatinized grains are also large and distorted as in that starch. In this reaction *T. crocosmæflora* shows a closer resemblance, qualitatively, to *T. crocosmia aurea* than to *T. pottsii*.

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 0.5 per cent of the grains and 6 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 11 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 16 per cent of the total starch in 30 minutes; in about 10 per cent of the grains and 23 per cent of the total starch in 45 minutes; in about 15 per cent of the grains and 31 per cent of the total starch in 60 minutes. (Chart D 497.)

The reaction with *uranium nitrate* begins in a few grains in half a minute. Complete gelatinization was not observed in any of the grains and 1 per cent of the total starch was gelatinized in 5 minutes; complete gelatinization occurs in about 2 per cent of the entire number of grains and 6 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 7 per cent of the total starch in 30 minutes; slight advance in gelatinization in 45 minutes; in about 5 per cent of the grains and 8 per cent of the total starch in 60 minutes. (Chart D 498.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 12 per cent of the total starch in 5 minutes; in about 16 per cent of the grains and 26 per cent of the total starch in 15 minutes; in about 25 per cent of the grains and 43 per cent of the total starch in 30 minutes; in about 30 per cent of the grains and 51 per cent of the total starch in 45 minutes; in about 40 per cent of the grains and 60 per cent of the total starch in 60 minutes. (Chart D 499.)

The reaction with *cobalt nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about the same percentage of the grains and 3 per cent of the total starch in 30 minutes; in about 2 per cent of the grains and 4 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 6 per cent of the total starch in 60 minutes. (Chart D 500.)

The reaction with *copper nitrate* begins in rare grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 15 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 17 per cent of the total starch in 30 minutes; in about 6 per cent of

the grains and 18 per cent of the total starch in 45 minutes; in about 7 per cent of the grains and 21 per cent of the total starch in 60 minutes. (Chart D 501.)

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 11 per cent of the total starch in 15 minutes; in about 7 per cent of the grains and 12 per cent of the total starch in 30 minutes; in about 9 per cent of the grains and 15 per cent of the total starch in 45 minutes; in about the same percentage of both the grains and total starch in 60 minutes. (Chart D 502.)

The reaction with *barium chloride* begins in rare grains in 1 minute. Complete gelatinization was not observed in any of the entire number of grains and 0.5 per cent of the total starch in 5 minutes; still no complete gelatinization noted and 1 per cent of the total starch in 15 minutes; very slight if any advance in 30 minutes; complete gelatinization occurs in but rare grains, less than 0.5 per cent of the grains and 2 per cent of the total starch in 45 minutes; no apparent advance in 60 minutes. (Chart D 503.)

The reaction with *mercuric chloride* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 6 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 9 per cent of the total starch in 30 minutes; in about 4 per cent of the grains and 10 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 11 per cent of the total starch in 60 minutes. (Chart D 504.)

11. BEGONIA.

This genus includes about 350 species, together with hundreds or thousands of garden varieties and a considerable list of hybrids. It has been divided horticulturally into four groups—the fibrous-rooted, semituberous, tuberous, and rex or ornamental-leaved. They are readily hybridized, and members of different groups have been crossed, as for instance, semituberous and tuberous, and semituberous and rex. In this research the starches from four sets of parent-stocks and hybrids were studied, the crosses being between *B. socotrana* Hook. (semituberous) and garden varieties of the tuberous group. *B. socotrana* is the pollen parent in each set. The specimens were obtained from the growers, James Veitch and Sons, London.

36. *B. single crimson scarlet* (seed parent), *B. socotrana* pollen parent), and *B. mrs. heal* (hybrid), page 695.
37. *B. double light rose* (seed parent), *B. socotrana* (pollen parent), and *B. ensign* (hybrid), page 702.
38. *B. double white* (seed parent), *B. socotrana* (pollen parent), and *B. julius* (hybrid), page 708.
39. *B. double dark rose* (seed parent), *B. socotrana* (pollen parent), and *B. success* (hybrid), page 713.

Examinations were made in full of only the first set. In the other sets the reaction-intensity studies were restricted to the reactions with polarization, iodine, gentian violet, safranin, temperature of gelatinization, chloral hydrate, chromic acid, pyrogallic acid, nitric acid, and strontium nitrate. The limitations in the latter were owing to the closeness of the reactions of the seed parents in all of the remaining reactions, excepting only those with cobalt nitrate, barium chloride, and mercuric chloride.

36. Starches of Begonia single crimson scarlet, B. socotrana, and B. mrs. heal.

Starch of *Begonia socotrana* (pollen parent) is described on pages 704 to 707.

Begonia single crimson scarlet (Seed Parent).

(Plate 21, fig. 121; Charts D 505 to D 526.)

Histologic Properties.

In *form* the grains are almost solely simple and isolated, a compound grain or an aggregate being occasionally seen. The compound grains belong to one type: 2 small grains, each consisting of a hilum and 1 or 2 lamellæ, both surrounded by 30 or more common secondary lamellæ, and attached to the proximal end of a large, elongated grain. The aggregates consist of 2 or 3 small, equal-sized grains, linearly or pyramidally arranged. The grains are moderately often irregular, and the irregularities are due to the following causes: (1) A set of secondary lamellæ whose longitudinal axis is at an angle of varying size with that of the primary set; (2) 1 or 2 rather small rounded protuberances from the sides or the proximal end; (3) a deviation of the axis and a consequent bending of the grain; (4) a greater development of either distal or proximal end than of the rest of the grain. In many of the grains the secondary formation is so much greater than the primary deposit that the latter appears as a small grain embedded in the proximal part of a large grain, which is often of the same but not infrequently of a very different shape. The conspicuous forms are rather broad elliptical, ovoid, round, and nearly round. The additional forms are rod-shaped, pyriform, and triangular. The few very broad forms are somewhat flattened, and when viewed on edge appear to have an elongated elliptical shape.

The *hilum* is a rather indistinct, small, round spot which is rarely fissured. When fissuring occurs, the fissures have the following forms: (1) A single, short, straight line transversely or obliquely placed; (2) an irregularly stellate arrangement of several fissures. The hilum is eccentric from 0.3 to 0.17, usually 0.25, of the longitudinal axis.

The *lamellæ* are usually fine and not very distinct. There is often one distinct, coarse, refractive lamella near the hilum, and another outlining the primary grain, if the grain has both primary and secondary starch formations. In addition there are often 3 or 4 broad refractive lamellæ which divide the fine lamellæ into bands of varying breadth. The lamellæ are more distinct near the distal end than near the hilum, and less distinct in the primary than in the secondary starch. The number on the grains can not be determined.

In *size* the grains vary from the smaller which are 4 by 4μ, to the larger which are 30 by 16μ, in length and breadth. The common sizes are 20 by 13μ and 18 by 14μ.

Comparison of the *histologic properties* between *B. socotrana* and *B. single crimson scarlet* shows:

Form.—No compound grains or aggregates, such as occur in *B. single crimson scarlet,* are seen in *B. socotrana.* The grains are not so often irregular as in *B. single crimson scarlet,* but the irregularities are usually more marked. The irregularities are due to the same causes as in *B. single crimson scarlet,* and also very commonly to: (1) 1 to 3 large or small, rounded or pointed protuberances from the proximal end or sides. The grains are much more elongated, and there are very few of the round forms, common in *B. single crimson scarlet.*

The *hilum* is somewhat distinct and somewhat more often fissured. The fissures have the same forms as in *B. single crimson scarlet,* and in addition: (1) A somewhat branched **Y** form; (2) a flying-bird form. The hilum is usually eccentric 0.18 of the longitudinal axis, which is 0.07 more eccentric than in *B. single crimson scarlet.*

The *lamellæ* are somewhat more distinct and less regular than in *B. single crimson scarlet.* There is never a very coarse, refractive lamella near the hilum, or one outlining the primary starch in the grain which consists of both primary and secondary starch deposits. Otherwise the characteristics and the arrangement are the same.

In *size* the grains are larger, the larger grains being 22μ longer and 6μ broader, and the common sizes 12μ longer and 1μ broader and 12μ longer and 7μ broader respectively than the corresponding common forms of *B. single crimson scarlet.*

Polariscopic Properties.

The *figure* is distinct and usually well defined. The lines are usually thin, but may be thick especially near the margin. They cross at an acute angle which does not vary greatly in size in the different grains. They are sometimes considerably bent, but usually are not bent, and are often bisected or even divided into 3 or 4 lines near the margin. The figure sometimes has the form of a conjugate hyperbola.

The *degree of polarization* varies from moderately high to high (value 60). There is very little variation in a given aspect of the individual grains.

With *selenite* the quadrants are usually clear-cut, but in a moderate number of grains they are not. They are unequal in size and usually regular but sometimes very irregular in shape. The colors are usually pure, except for a few, which have a greenish tinge.

Comparison of the *polariscopic properties* between *B. socotrana* and *B. single crimson scarlet* shows:

The figure is as distinct and better defined than in *B. single crimson scarlet.* The lines are always thin and not so often or so much bent, or bisected, or otherwise subdivided, as in *B. single crimson scarlet.* Figures in the form of a conjugate hyperbola are never seen.

The *degree of polarization* varies from moderately high to high (value 60), the same as in *B. single crimson scarlet.*

With *selenite* the quadrants are more often well defined, more unequal in size, and less often irregular in shape. The colors are usually pure and about the same number of grains have a greenish tinge as in *B. single crimson scarlet.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate blue-violet (value 45). The color deepens rapidly until it is very deep and has assumed more of a bluish tint. With 0.125 per cent Lugol's solution, the grains all color a light violet tinged with blue, and the color deepens with moderate rapidity until it is deep and has assumed more of a bluish tint. After heating in water until the grains are all gelatinized, the gelatinized *grains* all color a deep indigo, and the *solution* a moderate to deep indigo. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the *grain-residues* are usually only colored in the capsules, but a few are colored a moderate indigo; the *capsules* are all colored a moderate violet; and the *solution* a very deep indigo.

Comparison of the *iodine reactions* between *B. socotrana* and *B. single crimson scarlet* shows:

With 0.25 per cent Lugol's solution the grains all color a light to moderate violet tinged with blue (value 30), 15 units less than in *B. single crimson scarlet.* With 0.125 per cent Lugol's solution the grains are colored a very light violet, much less than in *B. single crimson scarlet.* After heating in water until all the grains are completely gelatinized, the grains are colored less and the solution more than in *B. single crimson scarlet.* If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution, all the grain-residues are more colored, the capsules more and the solution somewhat less deeply colored, than in *B. single crimson scarlet.*

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in half an hour they are light to moderately colored (value 45), most of the grains are colored moderately, a few are light to moderate, and a few moderate to high.

With *safranin* the grains all color very lightly at once, and in half an hour they are moderately to deeply colored (value 60). Most of the grains are moderately to deeply colored—a few moderately, and a few deeply colored.

Comparison of the *aniline reactions* between *B. socotrana* and *B. single crimson scarlet* shows:

With *gentian violet* the grains color light to moderately (value 35), 10 units less than in *B. single crimson scarlet.* There is a wider variation in the depth of color of different grains than in *B. single crimson scarlet.*

With *safranin* the grains color moderately (value 55), 5 units less than in *B. single crimson scarlet.* There is a wider variation in color in the different grains than in *B. single crimson scarlet.*

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 67° to 68.5° C., and of all 70° to 72° C., mean 71° C.

Comparisons of the *temperature reactions* between *B. socotrana* and *B. single crimson scarlet* shows:

The temperature of gelatinization is 81° to 81.8° C., mean 81.4° C., which is 10.4° C. higher than that of *B. single crimson scarlet.*

EFFECTS OF VARIOUS REAGENTS.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 81 per cent of the entire number of grains and 88 per cent of the total starch in 5 minutes; in more than 99 per cent of the grains and total starch in 10 minutes. (Chart D 505.)

The hilum becomes rather indistinct in all the grains, unattended by the formation of a bubble in any. The lamellæ are not visible. The grain grows more refractive after the addition of the reagent, and the first part of the grain to show this change is a rather narrow band of starch at the margin which becomes somewhat more refractive but not very much. Gelatinization begins at the distal margin at 1 or 2 discrete points which are first invaded by small cracks, and from these points it spreads over the whole distal margin, and then rapidly toward the proximal end, and usually more rapidly around the margin than in the center of the grain. The last part of the grain to be gelatinized is immediately surrounding the hilum, and as the hilum swells this usually is split into 2 or 3 pieces, which are widely separated and gelatinized independently of one another.

The gelatinized grains are much swollen, have moderately thick capsules, and considerably distorted.

Comparison of the *chloral hydrate* reactions between *B. socotrana* and *B. single crimson scarlet* shows:

The hilum is invisible, as are also the lamellæ. The grains become somewhat more refractive after the addition of the reagent than in *B. single crimson scarlet.* Gelatinization, as in the latter, begins at 2 or 3 discrete points on the margin and in the majority of the grains proceeds as in *B. single crimson scarlet,* except that the starch at the proximal margin is the last portion of the grain to be gelatinized instead of that immediately surrounding the hilum. In some of the grains the proximal end is gelatinized immediately after the distal end and the last part to be gelatinized is that midway between the hilum and the distal end. This method is not seen in *B. single crimson scarlet.* The gelatinized grains are as much swollen and more distorted than in *B. single crimson scarlet,* and have thin rather than thick capsules.

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 44 per cent of the entire number of grains and 85 per cent of the total starch in 5 minutes; in about 64 per cent of the grains and 98 per cent of the total starch in 15 minutes. (Chart D 506.)

Experiment repeated, showing 45 per cent of grains and 86 per cent of total starch in 5 minutes.

General Notes on Chromic Acid.—The time reactions with chromic acid are difficult to obtain with positive accuracy because there is a tendency for bubbles to appear in the solution, which may break, and either carry the grains under observation away from the field or force in new ones. Since there is considerable solution of all or a large part of some grains in all species with the exception of *B. socotrana,* when the number in the field changes because of the above-stated causes, it is impossible to be certain as to the original number of grains which were present at the beginning of the reaction. When changes are detected, and there is any considerable addition or subtraction, a new preparation must be made; and unless the preparation is constantly under observation, slight changes from shifting may occur, and hence to obtain a constant many observations should be made and an average percentage computed. In other experiments with *Begonia* starches in which the percentages at 5 minutes have appeared to be abnormally high, as in *B. double white,* the experiments have been repeated with practically identical results. With the latter starch the first experiment gave 75 per cent of the grains and 97 per cent of the total starch in 5 minutes, and the second experiment 75 per cent of the grains and 96 per cent of the total starch. The number of grains under observation in the first was 200 and in the second 140. These experiments were made on consecutive days.

It will be noted in these experiments that *B. socotrana* is very much slower in its time-reactions than all the other specimens, and that, while the hybrid more closely follows those of the seed parent, the influence of *B. socotrana* appears marked at the 5-minute observation in all these starches with the exception of *B. success.* The time reactions at 5 minutes were repeated with *B. double deep rose* and *B. success* in order to test the possibility of the number of grains changing because of the shifting above mentioned during the reaction, but the resulting percentages obtained were practically the same. (See note, page 705.)

The hilum becomes distinct in all the grains, unattended by the formation of a bubble in any. The lamellæ are indistinct or invisible. Gelatinization begins at the hilum which swells rapidly and more in the direction of the proximal than of the distal end. Two fissures are seen in many grains extending from either side of the hilum about half the distance between the hilum and the distal end, and the starch comprehended between them is usually gelatinized without any fissuring or granule formation. The resistant starch at the margin forms a thick, homogeneous-looking band which is thicker at the distal than at the proximal margin; this grows thinner and more refractive and is dissolved at the proximal end. Toward the end of the reaction the rest of the marginal band may be separated into 2 layers which dissolve separately.

Comparison of the *chromic-acid* reactions between *B. socotrana* and *B. single crimson scarlet* shows:

The hilum is as distinct as in *B. single crimson scarlet,* and the lamellæ are visible in all the grains, and usually very distinct. Gelatinization begins at the hilum which only swells slightly, instead of rapidly, and only somewhat more in the direction of the proximal than of the distal end. Two fissures extend from either side of the hilum, and the starch comprehended between them and immediately distal to the hilum is quickly divided by two rows of slanting fissures. This phenomenon is never seen in *B. single crimson scarlet,* the grain remains so without further change, except that it grows more refractive and is gradually divided into an outer homogeneous-looking layer and an inner granular mass. The outer layer is divided at one corner of the distal end and in some grains splits away from the inner granular portion which may or may not be dissolved first.

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 16 per cent of the entire number of grains and 58 per cent of the total starch in 5 minutes; in about 50 per cent of the grains and 88 per cent of the total starch in 15 minutes; in about 58 per cent of the grains and 92 per cent of the total starch in 30 minutes; in about 66 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 97 per cent of the total starch in 60 minutes. (Charts D 507 and D 508.)

The hilum becomes distinct in all the grains, unattended by the formation of a bubble in any. The lamellæ

are not distinct but are visible in all the grains. Gelatinization begins at the hilum, which enlarges more rapidly toward the proximal than toward the distal end. Two fissures are formed which extend from either side of the hilum about three-fourths of the way from the hilum to the distal margin. The part of the grain between these fissures gelatinizes rather slowly, usually without any preliminary fissuring, so that the gelatinizing grain presents the appearance of a broad, homogeneous-looking band of refractive material, surrounding a central, clear space. This band is much broader and thicker at the distal than at the proximal end. It grows gradually thinner and more nearly transparent, and is finally gelatinized. The gelatinized grains are much swollen, have rather thin walls, and are considerably distorted.

NOTE. The pyrogallic-acid solution used in the qualitative experiments was composed of 6 grams of pyrogallic acid, 0.3 gram of oxalic acid, and 35 c.c. of distilled water, and therefore stronger than the solution in the quantitative reactions.

Comparison of the *pyrogallic-acid* reactions between *B. socotrana* and *B. single crimson scarlet* shows:

The hilum and lamellæ are more distinct than in *B. single crimson scarlet*. Gelatinization begins at the hilum which swells slightly, but no more in the direction of the proximal than of the distal end. Two fissures appear which extend from either side of the hilum only about half the distance between the hilum and the distal end, and proceeds from this point quite differently from that seen in *B. single crimson scarlet*. The starch between the 2 fissures is divided by a double row of slanting fissures which become more distinct as the grain swells somewhat. Finally, it is gelatinized slowly, leaving a refractive, granular residue at the distal end. The material at the proximal and distal margins and sides forms a thick, refractive, lamellated marginal band. No further change takes place within an hour except an increased refractivity of the whole grain.

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in 100 per cent of the entire number of grains and total starch in 15 seconds. (Chart D 509.)

The hilum becomes distinct in all the grains, attended by the formation of a bubble in a majority of them. The lamellæ are not very distinct, but are visible. Gelatinization begins at the hilum which swells very rapidly, especially toward the proximal end. Two fissures appear extending from either side of the hilum to about half the distance to the distal end. The portion comprehended between them is not fissured, but gelatinizes very rapidly, so that the gelatinizing grain shows merely a refractive, homogeneous-looking marginal band surrounding a central area. This band is broader and thicker at the distal than at the proximal end, and the distal starch is the last to be completely gelatinized. If a bubble is present at the hilum it first swells as the hilum enlarges, then shrinks, and finally disappears, causing an invagination of the marginal band and capsule at the side. The gelatinized grains are much swollen, have rather thin capsules, and are not much distorted.

Comparison of the *nitric-acid* reactions between *B. socotrana* and *B. single crimson scarlet* shows:

The hilum becomes distinct in all the grains, unattended by the formation of a bubble. The lamellæ are more distinct than in *B. single crimson scarlet*. Gelatinization begins at the hilum, but proceeds differently from *B. single crimson scarlet*. Two fissures are formed extending from the hilum on either side nearly to the distal margin. The starch comprehended between them and immediately distal to the hilum is divided by a double row of slanting fissures which are at first indistinct but later become distinct. This fissured material is slowly gelatinized, leaving small pointed protuberances of refractive starch projecting from the sides into the area of the swelling grain. This is as far as the reaction ever seems to go in the normal grains.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 97 per cent of the entire number of grains and 98 per cent of the total starch in 15 seconds; in 100 per cent of the grains and total starch in 30 seconds. (Chart D 510.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 92 per cent of the entire number of grains and 96 per cent of the total starch in 30 seconds; in 100 per cent of the grains and total starch in 1 minute. (Chart D 511.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in 100 per cent of the entire number of grains and total starch in 10 seconds or earlier (apparently instantaneous). (Chart D 512.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 85 per cent of the entire number of grains and 99 per cent of the total starch in one minute and 30 seconds. (Chart D 513.)

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 80 per cent of the entire number of grains and in more than 99 per cent of the total starch in 30 seconds; in about 90 per cent of the grains and in more than 99 per cent of the total starch in 1 minute. (Chart D 514.)

The reaction with *potassium sulphide* begins immediately. Complete gelatinization is apparently instantaneous, as all grains are gelatinized as soon as an observation can be made. (Chart D 515.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in 100 per cent of the grains and total starch in 15 seconds. (Chart D 516.)

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 97 per cent of the entire number of grains and in more than 99 per cent of the total starch in 1 minute. (Chart D 517.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 93 per cent of the grains and 97 per cent of the total starch in 3 minutes; in more than 99 per cent of the grains and total starch in 5 minutes. (Chart D 518.)

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in 88 per cent of the entire number of grains and 99 per cent of the total starch in 2 minutes; in about 95 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 519.)

The reaction with *uranium nitrate* begins immediately. Complete gelatinization occurs in about 97 per cent of the entire number of grains and in more than 99

per cent of the total starch in 2 minutes; in more than 99 per cent of the grains and total starch in 3 minutes. (Chart D 520.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 89 per cent of the entire number of grains and 96 per cent of the total starch in 1 minute; in 100 per cent of the grains and total starch in 2 minutes. (Chart D 521.)

The hilum becomes distinct, unattended by the formation of a bubble in any of the grains. The lamellæ are never distinct and are usually not visible. Gelatinization begins at the hilum which swells rapidly, more toward the proximal than toward the distal end. Two fissures are rarely seen to extend from either side of the hilum toward the distal margin. Usually the hilum simply enlarges rapidly, and the more resistant starch of the grain forms a thick, refractive, homogeneous-looking marginal band which is much thicker and broader at the distal than at the proximal end and sides. This marginal band grows thinner, and more nearly transparent, and is finally gelatinized, first at the proximal and last at the distal end. In the grains in which 2 fissures extend from either side of the hilum, there is no other difference to be noted in the methods of gelatinization. The gelatinized grains are much swollen, have rather thick capsules, and are somewhat distorted.

Comparison of the *strontium-nitrate* reactions between *B. socotrana* and *B. single crimson scarlet* shows:

The hilum and lamellæ are more distinct than in *B. single crimson scarlet*. Gelatinization begins at the hilum and progresses rather differently from *B. single crimson scarlet*. The hilum swells somewhat, and 2 distinct fissures proceed from either side nearly to the distal margin, the starch comprehended between them is fissured by fine longitudinal fissures, and then in many grains by a double row of slanting fissures which appear first near the hilum and then progressively toward the distal end as the starch near the hilum is gelatinized and the grain swells. As the starch thus fissured is gelatinized it leaves a residue of small refractive protuberances projecting into the interior of the swelling grains. The starch at the proximal end and sides forms at the margin a homogeneous-looking refractive band which is moderately rapidly gelatinized. The gelatinized grains are more swollen, do not have such thick capsules, and are more distorted than in *B. single crimson scarlet*.

The reaction with *cobalt nitrate* begins immediately. Complete gelatinization occurs in about 36 per cent of the entire number of grains and 70 per cent of the total starch in 5 minutes; in about 56 per cent of the grains and 88 per cent of the total starch in 15 minutes; in about 65 per cent of the grains and 93 per cent of the total starch in 30 minutes; in about 68 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 71 per cent of the grains and 96 per cent of the total starch in 60 minutes. (Chart D 522.)

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 90 per cent of the entire number of grains and 99 per cent of the total starch in 2 minutes; in 100 per cent of the grains and total starch in 5 minutes. (Chart D 523.)

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 75 per cent of the entire number of grains and in more than 99 per cent of the total starch in 3 minutes; in about 87 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 524.) The grains are very quickly gelatinized with the exception of a small area at the distal margin.

The reaction with *barium chloride* begins in a few grains in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 7 per cent of the grains and 23 per cent of the total starch in 15 minutes; in about 32 per cent of the grains and 62 per cent of the total starch in 30 minutes; in about 39 per cent of the grains and 66 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 525.)

The reaction with *mercuric chloride* begins immediately. Complete gelatinization occurs in about 35 per cent of the entire number of grains and 80 per cent of the total starch in 5 minutes; in about 74 per cent of the grains and 96 per cent of the total starch in 15 minutes; in about 80 per cent of the grains and 98 per cent of the total starch in 30 minutes; in about 82 per cent of the grains and 99 per cent of the total starch in 45 minutes; in about 86 per cent of the grains and in more than 99 per cent of the total starch in 60 minutes. (Chart D 526.)

Begonia mrs. heal (Hybrid).

(Plate 21, fig. 123; Charts D 505 to D 526.)

Histologic Properties.

In *form* the grains are almost solely simple and isolated, a compound grain or an aggregate may be seen of the same types as described under *B. single crimson scarlet*. The grains are usually regular—somewhat more often irregular than in *B. socotrana,* and somewhat less often than in *B. single crimson scarlet*. The irregularities are due to the same causes as described under *B. socotrana* with the addition of a deviation of the axis in two different directions with a consequent bending of the grain at both ends. This is not seen in either parent. The conspicuous forms are elongated elliptical and ovoid. The additional forms are round and nearly round, irregularly triangular, quadrilateral with rounded corners, rod-shaped, and, rarely, oyster-shell-shaped. The few broad forms are somewhat flattened, as in both parents, and when seen on edge have an elongated elliptical or ovoid shape. In form *B. mrs. heal* shows a closer relationship to *B. socotrana* than to *B. single crimson scarlet*.

The *hilum,* as in *B. single crimson scarlet,* is a rather indistinct, small, round spot which is rarely fissured. When fissuring occurs the forms are the same as in *B. single crimson scarlet*. The hilum is eccentric from 0.3 to 0.17, usually 0.18, of the longitudinal axis, which is the same as in *B. socotrana* and 0.07 more eccentric than in *B. single crimson scarlet*. In the character of the hilum *B. mrs. heal* shows a closer relationship to *B. single crimson scarlet,* and in the eccentricity to *B. socotrana*.

The *lamellæ* are more distinct and are not so fine as in the parents, resembling *B. socotrana* more closely. Otherwise the characteristics and the arrangement of the lamellæ are the same as in *B. socotrana,* except that when the grain is composed of both primary and secondary parts the primary grain is surrounded by a single, broad, refractive lamella, as in *B. single crimson scarlet*. The

number counted on the larger grains varies from 30 to 42, usually 38. In the character and the arrangement of the lamellæ *B. mrs. heal* shows a closer relationship to *B. socotrana* than to *B. single crimson scarlet*.

In *size* the grains vary from the smaller which are 6 by 5μ, to the larger which are 48 by 26μ, in length and breadth, the common size is 30 by 16μ, which is 2μ shorter and 2μ broader than the corresponding size in *B. socotrana*, and 10μ longer and 3μ broader than the corresponding size in *B. single crimson scarlet*. In size *B. mrs. heal* shows a closer relationship to *B. socotrana* than to *B. single crimson scarlet*.

Polariscopic Properties.

The *figure* is as distinct and as well defined as in *B. single crimson scarlet*. The lines, however, are thin as in *B. socotrana*, and cross at a very acute angle which does not vary greatly in size in different grains as in that starch. They are as much bent and as often bisected as in *B. single crimson scarlet*. Rarely the figure has the form of a conjugate hyperbola.

The *degree of polarization* varies from moderate to moderately high (value 65), 5 units more than in either parent. There is little variation in a given aspect of an individual grain as in both parents.

With *selenite* the quadrants are as clear-cut as in *B. single crimson scarlet*, and are as irregular in shape as in that starch. The colors are as pure as in both parents, and there are more grains which have a greenish tinge than in either.

In the degree of polarization, in which respect the two parents are the same, the hybrid is higher than either.

In the character of the figure and the appearances with selenite, *B. mrs. heal* shows a somewhat closer relationship to *B. single crimson scarlet* than to *B. socotrana*.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate blue-violet (value 45), the same as in *B. single crimson scarlet* and 15 units more than in *B. socotrana*. With 0.125 per cent Lugol's solution the grains all color a light violet tinged with blue, the same as in *B. single crimson scarlet* and more than in *B. socotrana*. After heating in water until the grains are all completely gelatinized, then treating with a 2 per cent Lugol's solution, the gelatinized *grains* are all colored a deep or moderate to deep indigo, somewhat less than in *B. single crimson scarlet*, but more than in *B. socotrana;* and the *solution* a moderately deep indigo as in *B. single crimson scarlet*. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the majority of the *grain-residues* are not colored, except the capsules, as in *B. single crimson scarlet*, the remainder are colored light to moderately, somewhat more than in *B. single crimson scarlet*, but much less than in *B. socotrana;* the *capsules* a moderate violet; and the *solution* a very deep indigo, as in *B. single crimson scarlet*. Qualitatively and quantitatively the reactions with iodine show a closer relationship to *B. single crimson scarlet* than to *B. socotrana*.

Aniline Reactions.

With *gentian violet* the grains all color lightly at once, and in 30 minutes they are all moderately colored (value 45), the same as in *B. single crimson scarlet* and 10 units more than in *B. socotrana*.

With *safranin* the grains all color lightly at once, and in 30 minutes they are all moderately to deeply colored (value 60), the same as in *B. single crimson scarlet* and 5 units more than in *B. socotrana*.

In these reactions with aniline stains *B. mrs. heal* shows a closer relationship to *B. single crimson scarlet* than to *B. socotrana*.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 67° to 69° C., and of all 71° to 72° C., the mean 71.5° C., which is 0.5° C. higher than in *B. single crimson scarlet* and 9.9° C. lower than in *B. socotrana*. The temperature of gelatinization of *B. mrs. heal* is much closer to that of *B. single crimson scarlet* than to that of *B. socotrana*.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 57 per cent of the entire number of grains and 68 per cent of the total starch in 5 minutes; in about 94 per cent of the grains and 97 per cent of the total starch in 10 minutes. (Chart D 505.)

The hilum is indistinct as in *B. single crimson scarlet*, and the lamellæ are not visible as in both parents. The grains become more refractive after the addition of the reagent, and the first portion of the grain to show this change is a rather narrow band of starch around the margin, which is as narrow and as refractive as in *B. socotrana*. Gelatinization begins at 2 or 3 discrete points on the distal margin, and in the majority of the grains progresses as in *B. single crimson scarlet*. A rather small minority gelatinizes as in *B. socotrana*.

The gelatinized grains are as much swollen and as much distorted as in *B. single crimson scarlet*, but have rather thin capsules as in *B. socotrana*.

In this reaction *B. mrs. heal* shows qualitatively a closer relationship to *B. single crimson scarlet* than to *B. socotrana*.

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 20 per cent of the total starch in 5 minutes; in about 31 per cent of the grains and 67 per cent of the total starch in 15 minutes; in about 54 per cent of the grains and 95 per cent of the total starch in 30 minutes. (Chart D 506.) (See page 697.)

The hilum and the lamellæ are as distinct as in *B. socotrana*. Gelatinization begins at the hilum and progresses as in *B. single crimson scarlet*, except that the starch distal to the hilum and comprehended between the 2 fissures from the hilum is always fissured by fine branching lines and in some grains is also divided by a double row of slanting fissures as in *B. socotrana*. In this reaction *B. mrs. heal* shows qualitatively a closer relationship to *B. single crimson scarlet* than to *B. socotrana*.

The reaction with *pyrogallic acid* begins in a few grains in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 25 per cent of the total starch in 15 minutes; in about 16 per cent of the grains and 58 per cent of the total starch in 30 minutes; in about 29 per cent of the grains and 66 per cent of the total

starch in 45 minutes; in about 33 per cent of the grains and 71 per cent of the total starch in 60 minutes. (Chart D 507.)

The hilum and lamellæ are as distinct as in *B. socotrana.* Gelatinization begins at the hilum and proceeds as in *B. single crimson scarlet,* except that in a few grains the starch comprehended between the 2 fissures from the hilum is divided by a double row of slanting fissures and gelatinizes slowly, leaving a refractive granular residue as in *B. socotrana.* The gelatinized grains are as much swollen, have as thin capsules, and are as much distorted as in *B. single crimson scarlet.*

In this reaction *B. mrs. heal* shows, qualitatively, a closer relationship to *B. single crimson scarlet* than to *B. socotrana.* (See note, page 698.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 90 per cent of the entire number of grains and 95 per cent of the total starch in 15 seconds; in more than 99 per cent of the grains and total starch in 30 seconds. (Chart D 509.)

The hilum and lamellæ are as distinct as in *B. socotrana.* Gelatinization begins at the hilum and proceeds as in *B. single crimson scarlet,* except that the starch comprehended between the 2 fissures, which proceed from the hilum, is fissured usually somewhat irregularly, sometimes by a double row of slanting fissures showing the influence of *B. socotrana;* and a refractive granular residue often remains at the distal end after this part of the grain is gelatinized. The gelatinized grains are as much swollen as in *B. single crimson scarlet,* but they have thinner capsules and are somewhat more distorted. In this reaction *B. mrs. heal* shows qualitatively a closer relationship to *B. single crimson scarlet* than to *B. socotrana.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 85 per cent of the entire number of grains and 90 per cent of the total starch in 15 seconds; in more than 99 per cent of the grains and total starch in 30 seconds. (Chart D 510.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in 100 per cent of the entire number of grains and 87 per cent of the total starch in 30 seconds; in about 87 per cent of the grains and 99 per cent of the total starch in 1 minute; in about 98 per cent of the grains and in more than 99 per cent of the total starch in 2 minutes. (Chart D 511.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in 100 per cent of the entire number of grains and total starch in 10 seconds or earlier (apparently instantaneous). (Chart D 512.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 50 per cent of the entire number of grains and 89 per cent of the total starch in 1 minute; about 95 per cent of the total starch in 3 minutes; in about 90 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 513.)

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 66 per cent of the entire number of grains and 95 per cent of the total starch in 30 seconds; in about 78 per cent of the grains and 99 per cent of the total starch in 1 minute; in more than 99 per cent of the grains and total starch in 5 minutes. (Chart D 514.)

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 95 per cent of the entire number of grains and 99 per cent of the total starch in 15 seconds; in 100 per cent of the grains and total starch in 30 seconds. (Chart D 515.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 50 per cent of the entire number of grains and 80 per cent of the total starch in 15 seconds; in 70 per cent of the grains and 93 per cent of the total starch in 30 seconds; in about 95 per cent of the grains and in more than 99 per cent of the total starch in 1 minute. (Chart D 516.)

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 56 per cent of the entire number of grains and 90 per cent of the total starch in 1 minute; in about 97 per cent of the grains and 99 per cent of the total starch in 5 minutes. (Chart D 517.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 59 per cent of the entire number of grains and 72 per cent of the total starch in 3 minutes; in about 86 per cent of the grains and 96 per cent of the total starch in 5 minutes; in more than 99 per cent of the grains and total starch in 10 minutes. (Chart D 518.)

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 14 per cent of the entire number of grains and 59 per cent of the total starch in 2 minutes; in about 40 per cent of the grains and 84 per cent of the total starch in 5 minutes; in about 76 per cent of the grains and 98 per cent of the total starch in 15 minutes. (Chart D 519.)

A small area at the distal margin is very resistant and may remain ungelatinized in a number of grains at the end of 60 minutes.

The reaction with *uranium nitrate* begins in 30 seconds. Complete gelatinization occurs in about 33 per cent of the entire number of grains and 84 per cent of the total starch in 2 minutes; in about 75 per cent of the grains and 99 per cent of the total starch in 5 minutes; in about 98 per cent of the grains and in more than 99 per cent of the total starch in 15 minutes. (Chart D 520.)

The reaction with *strontium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 22 per cent of the total starch in 1 minute; in about 78 per cent of the grains and 90 per cent of the total starch in 2 minutes; in about 95 per cent of the grains and in more than 99 per cent of the total starch in 3 minutes. (Chart D 521.)

The hilum and lamellæ are as distinct as in *B. socotrana.* Gelatinization begins at the hilum and progresses as in *B. single crimson scarlet,* except that 2 fissures proceeding from either side of the hilum are seen in more grains than in that starch. The gelatinized grains are as much swollen and have as thick capsules as in *B. single crimson scarlet,* but are somewhat more distorted than in those grains, but less than in *B. socotrana.* In this reaction *B. mrs. heal* shows qualitatively a somewhat closer relationship to *B. single crimson scarlet* than to *B. socotrana.*

The reaction with *cobalt nitrate* begins in a few grains in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 10 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 27 per cent of the total starch in 30 minutes; in about 14 per cent of the grains and 44 per cent of the total starch in 45 minutes; little if any advance in 60 minutes. (Chart D 522.)

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 50 per cent of the entire number of grains and 80 per cent of the total starch in 2 minutes; in about 73 per cent of the grains and 95 per cent of the total starch in 5 minutes; in about 90 per cent of the grains and in more than 99 per cent of the total starch in 15 minutes. (Chart D 523.)

The reaction with *cupric chloride* begins in a few grains in 30 seconds. Complete gelatinization occurs in about 20 per cent of the entire number of grains and 75 per cent of the total starch in 3 minutes; in about 44 per cent of the grains and 90 per cent of the total starch in 5 minutes; in about 70 per cent of the grains and 98 per cent of the total starch in 15 minutes. (Chart D 524.)

A small area at the distal end in a number of grains is very resistant and a small percentage of grains (about 10 per cent) may still be ungelatinized at this point in 60 minutes. This part of the grain is much more resistant than in *B. single crimson scarlet,* but the grains are much less resistant than in *B. socotrana.*

The reaction with *barium chloride* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire nnmber of grains and 1 per cent of the total starch in 5 minntes; in about 1 per cent of the grains and 8 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 11 per cent of the total starch in 30 minutes; in about 4 per cent of the grains and 16 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 525.)

The reaction with *mercuric chloride* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 10 per cent of the grains and 30 per cent of the total starch in 15 minutes; in about 33 per cent of the grains and 63 per cent of the total starch in 30 minutes; in about 39 per cent of the grains and 71 per cent of the total starch in 45 minutes; in about 44 per cent of the grains and 80 per cent of the total starch in 60 minutes. (Chart D 526.)

37. Starches of Begonia double light rose, B. socotrana, and B. ensign.

Begonia double light rose (Seed Parent).

(Plate 21, fig. 124; Charts D 527 to D 532.)

Histologic Properties.

In *form* the grains are always simple and usually isolated. An occasional doublet or quadruplet is seen. The grains are usually regular in form, and any irregularities that occur are slight and due to the following causes: (1) A slight deviation of the longitudinal axis of the grain and a consequent bending of the grain; (2) a greater development of one side, or of the proximal end or of one portion of the distal end than the rest; (3) an occasional depression in the margin, usually at the distal end; (4) rarely, 1 or 2 large protuberances from the side; (5) rarely, secondary lamellæ whose axis is at a right or an acute angle to the axis of the primary set. The conspicuous forms are elliptical with squared or rounded distal end, ovoid, and nearly round. The additional forms are round, pyriform, and club-shaped. The grains are not flattened.

The *hilum* is a moderately distinct, round spot which is usually not fissured. The fissures, when present, have the following forms: (1) A single short, straight line; (2) a small, irrregular Y- or T-shape; (3) an irregularly stellate arrangement of a number of short fissures. The hilum is rarely centric, and in the great majority of the grains is eccentric from 0.44 to 0.29, commonly 0.31, of the longitudinal axis.

The *lamellæ* are fine and moderately distinct. Near the hilum they are continuous, round rings, and near the margin they become discontinuous and have the form of the outline of the grain. In some grains they are more distinct and less fine near the hilum, and in others near the distal end. In most of the grains there is a coarse, more or less refractive lamella situated one-fourth, one-half, or five-sixths of the distance from the hilum to the margin, and in some grains there is a band of 3 or 4 such coarse lamellæ about one-half to two-thirds of the way from the hilum to the margin. The number of lamellæ counted on the larger grains varies from 15 to 33, usually 24.

In *size* the grains vary from the smaller which are 6 by 6μ, to the larger which are 34 by 27μ, in length and breadth. The sizes are 24 by 20μ and 18 by 18μ in length and breadth.

Polariscopic Properties.

The *figure* is distinct and well defined. The lines are rather thick and cross at a right angle or at an acute angle which does not vary greatly in different grains. They are often somewhat bent and occasionally bisected.

The *degree of polarization* varies from moderately high to high (value 70). There is no variation in a given aspect of an individual grain.

With *selenite* the quadrants are clear-cut, and usually unequal in size, and often somewhat irregular in shape. The colors are usually pure, with the exception of a moderate number of grains which have a greenish tinge.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate blue tinged with violet (value 45). The color deepens rapidly until it is very deep and has assumed more of a bluish tint. With 0.125 per cent Lugol's solution the grains all color a light blue-violet, and the color deepens rapidly until it is deep. After heating in water until the grains are all gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* usually color a moderately light, a few a light, and a few a deep indigo; and the *solution* a deep indigo. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solu-

tion, the *grain-residues* all color a light to moderate indigo at their proximal ends; the *capsules* a deep violet; and the *solution* a very deep indigo.

Aniline Reactions.

With *gentian violet* the grains all color lightly at once, and in 30 minutes they are light to moderately colored (value 40). A majority of the grains are colored moderately, a moderate minority lightly, and a few deeply.

With *safranin* the grains all color lightly at once, and in 30 minutes they are moderate to deeply colored (value 60). More of the grains are deeply colored than in gentian violet, and very few are lightly colored.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 60° to 61° C., and of all 62° to 64° C., mean 63° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 61 per cent of the entire number of grains and 70 per cent of the total starch in 5 minutes; in about 94 per cent of the grains and 96 per cent of the total starch in 10 minutes. (Chart D 527.)

The hilum becomes rather indistinct, unattended by the formation of a bubble in any of the grains. The lamellæ are not visible. The grains become somewhat more refractive after the addition of the reagent, and the first part of the grain to show this change is a rather narrow band of material at the margin. Gelatinization begins at the distal margin and from this point proceeds smoothly toward the margin. In some grains it is preceded by a pitted appearance of the ungelatinized material, and in others not. It usually proceeds more rapidly along the margin than in the interior of the grain until the margin is reached; at this point in the reaction a bubble sometimes develops and swells, largely unaccompanied by swelling of the hilum, then shrinks and disappears. The starch at the proximal margin is next gelatinized and last the material immediately surrounding the hilum, and this is often split into 2 or 3 pieces which are widely separated and gelatinize independently of one another. The gelatinized grains are somewhat swollen, have thick capsules, and are usually considerably distorted but still retain some resemblance to the form of an untreated grain.

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 37 per cent of the entire number of grains and 77 per cent of the total starch in 5 minutes; in about 44 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 80 per cent of the grains and 99 per cent of the total starch in 30 minutes. (Chart D 528.) (See page 697.)

The hilum becomes distinct, unaccompanied by the formation of a bubble in any of the grains. The lamellæ are moderately distinct. Gelatinization begins at the hilum which swells rapidly toward the proximal end. Two fissures extend from either side of the hilum three-fourths of the distance to the distal margin. The starch comprehended between these fissures at first merely grows smaller in amount, and then as the grain swells it is fissured by irregular slanting fissures, beginning in the portion near the hilum, which divide it into coarse irregular granules. Before this process is far advanced the proximal end is dissolved, but solution of the grain does not advance far until the greater part of the distal granular portion is gelatinized and only a refractive residue is left. In the meantime the outer lamellated layer is partially separated from the inner refractive granular residue of the grain, and the two are dissolved separately.

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 22 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 76 per cent of the total starch in 15 minutes; in about 40 per cent of the grains and 92 per cent of the total starch in 30 minutes; in about 64 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 66 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Charts D 529 and D 530.)

The hilum becomes distinct, unattended by the formation of a bubble in any of the grains. The lamellæ are distinct in a great majority of the grains, but in some are not. Gelatinization begins at the hilum which enlarges slowly. The starch just distal to the hilum becomes indistinctly fissured, and refractive in appearance, and all the distal material slowly grows smaller in amount, finally forming a refractive granular mass at the distal end. The starch at the proximal and distal margin and sides forms a thick, very refractive band which slowly becomes thinner and more nearly transparent until it is gelatinized and only the capsule remains. The granular mass at the distal margin is gradually gelatinized at the same time, with some distortion of the capsule at this point. This mass is not seen in all the grains, but only in a rather small majority; in the others only an added thickness of the marginal band at the distal end is to be noted, and in such grains the capsule is not distorted at the distal end.

The gelatinized grains are moderately swollen, have thick capsules, and are not greatly distorted, but more in some grains than in others. (See note, page 698.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 90 per cent of the entire number of grains and 95 per cent of the total starch in 15 seconds; in more than 99 per cent of the grains and total starch in 30 seconds. (Chart D 531.)

The hilum becomes distinct in all the grains, attended by the formation of a bubble in a majority of them. The lamellæ are moderately distinct. Gelatinization begins at the hilum which swells rapidly, more rapidly toward the proximal than toward the distal end. Two indistinct fissures extend from either side of the hilum nearly to the distal margin and the part of the grain between them is indistinctly and irregularly fissured. The bubble swells first, then shrinks, and finally disappears, and a permanent invagination of one side of the grain occurs at the same time. The distal portion is rapidly gelatinized, leaving a small refractive granular residue at the distal end, which, as the refractive homogeneous-looking band at the margin grows gradually thinner and more nearly transparent, more or less slowly gelatinizes, with considerable distortion of the capsules at

the distal end. The gelatinized grains are much swollen, have rather thick capsules, and are somewhat distorted.

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 62 per cent of the entire number of grains and 77 per cent of the total starch in 1 minute; in about 96 per cent of the entire number of grains and 98 per cent of the total starch in 2 minutes. (Chart D 532.)

The hilum becomes distinct in all the grains, unattended by the formation of a bubble in any. The lamellæ become moderately distinct. Gelatinization begins at the hilum which swells rapidly more in the direction of the proximal than of the distal end. Two fissures are sometimes seen to extend from either side of the hilum about three-fourths of the distance from the hilum to the distal margin and, if these are present, the starch comprehended between them is indistinctly fissured and gelatinizes rapidly, leaving only a small, irregular, refractive residue at the distal end. If the 2 fissures are not present there is no other fissuring visible in the grain. The hilum swells, and a broad, refractive, homogeneous-looking band is formed at the margin which is much broader at the distal than at the proximal end of the grain. In both cases as the grain swells two deep invaginations of the capsule occur which are later straightened out. The gelatinized grains are much swollen, have moderately thick capsules, and are somewhat distorted.

Starch of Begonia socotrana (Pollen Parent).

(Plates 21 and 22, figs. 122, 125, 128, and 131; Charts D 505 to D 526.)

Histologic Properties.

In *form* the grains are always simple and isolated. Not even a few aggregates are seen as in *B. double light rose*. The grains are usually regular, but irregularities occur much more frequently than in *B. double light rose*. Irregularities are due to the following causes: (1) Most frequently, 1, 2, or more, large rounded or pointed protuberances from the proximal end or sides; (2) a greater development of one part of the distal end of the grain than of the rest; (3) a deviation of the axis and a consequent bending of the grain; (4) rarely, elevations and depressions of the distal end, producing in some grains a somewhat fluted appearance; (5) rarely a secondary set of lamellæ whose axis is at an angle with that of the primary set. The conspicuous forms are long, slender ovoid, and elliptical, the latter sometimes with flattened distal end. The additional forms are irregularly quadrilateral with rounded angles, irregularly boot-shaped, rod-shaped, club-shaped, and triangular. Some of the grains of this specimen are much sharpened at the distal end as if eroded. The grains, as in *B. double light rose,* are usually not flattened, but some of the rare broad forms are somewhat flattened, and when seen on edge have an ovoid shape.

The *hilum* is somewhat less distinct and somewhat more often fissured than in *B. double light rose,* but not in the majority of the grains. The fissures have the following forms: (1) A single, straight, or curved line transversely or obliquely placed; (2) a somewhat branched Y-shape; (3) rarely, an irregularly stellate arrangement of several fissures; (4) rarely, a flying-bird form. The hilum is apparently never centric, and is more eccentric than in *B. double light rose*. It is eccentric from 0.3 to 0.15, usually 0.18, of the longitudinal axis, which is 0.13 more eccentric than in *B. double light rose*.

The *lamellæ* are fine and not so distinct as in *B. double light rose*. Near the hilum they are round and continuous, and in the rest of the grain are discontinuous and follow the form of the contour of the grain, but show an occasional waviness of outline. The lamellæ are always more distinct at the distal than at the proximal end, instead of sometimes more distinct at the proximal than at the distal end, as in *B. double light rose*. There are often 1 to 3 or more broad refractive lamellæ situated about half the distance from the hilum to the distal margin. The number counted on the larger grains varies from 28 to 38, usually 33, more numerous than in *B. double light rose*.

In *size* the grains vary from the smaller which are 10 by 6μ, to the larger which are 52 by 22μ, in length and breadth. The common sizes are 30 by 21μ and 32 by 14μ, larger than in *B. double light rose*.

Polariscopic Properties.

The *figure* is distinct and is either moderately or very well defined. The lines always cross at an acute angle which varies considerably in size in the different grains, much more than in *B. double light rose*. They are usually not so thick as in *B. double light rose,* and are much less frequently bent, but more often bisected.

The *degree of polarization* varies from moderate to moderately high (value 60), 10 units less than in *B. double light rose*. There is some variation in a given aspect of a few grains. This is not seen at all in *B. double light rose*.

With *selenite* the quadrants are moderately to very clear-cut. They are more unequal in size than in *B. double light rose* and somewhat less often irregular in shape. The colors are often not so pure as in *B. double light rose,* and there is a much smaller number of grains which have a greenish tinge.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a light violet (value 30), 15 units less than in *B. double light rose;* the color deepens rather slowly and at the same time assumes more of a bluish tint, until it is moderately deep. With 0.125 per cent Lugol's solution, the grains all color a very light violet, much less than in *B. double light rose,* and the color deepens slowly until it is moderate and has assumed a somewhat bluish tint. After heating in water until the grains are all gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* are all colored a moderately light to deep blue tinged with violet, more than in *B. double light rose;* and the *solution* a deep indigo-blue, less than in *B. double light rose*. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the *grain-residues* all color a moderate indigo at the proximal end more than in *B. double light rose;* the *capsules* a very deep violet, deeper than in *B. double light rose;* and the *solution* a very deep indigo blue, as in *B. double light rose*.

Aniline Reactions.

With *gentian violet* the grains all color lightly at once, and in 30 minutes they are lightly to moderately colored (value 35), 5 units less than in *B. double light rose*.

Most of the grains are colored moderately lightly, a few lightly, and a very few deeply.

With *safranin* the grains all color lightly at once, and in 30 minutes they are moderately colored (value 55), 5 units less than in *B. double light rose;* few of the grains are colored lightly, the majority moderately, and a moderate number deeply.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 79° to 80° C., and of all 81° to 81.8° C., mean 81.4° C. The mean is 18.4° higher than in *B. double light rose.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 25 per cent of the entire number of grains and 38 per cent of the total starch in 5 minutes; in about 72 per cent of the grains and 79 per cent of the total starch in 10 minutes; in the entire number of grains and 38 per cent of the total starch in 15 minutes. (Charts D 505 and D 527.)

The hilum is invisible and bubble formation is not noted in any of the grains. The lamellæ also are invisible. The grains become more refractive after the addition of the reagent, and the first part of the grain to show this change is a rather narrow band of starch at the margin which becomes more refractive than in *B. double light rose.* Gelatinization begins at 1 or 2 discrete points on the distal margin which are first cracked, and then follows two methods: In the first, which is seen in a small majority, the process spreads from these points along the whole distal margin, and thence toward the hilum, never preceded by a pitted appearance of the ungelatinized starch as in *B. double light rose.* When the hilum is reached it swells, and the proximal starch is rapidly gelatinized. In the second method, the proximal end is gelatinized soon after the distal end, and gelatinization proceeds more rapidly from the proximal than from the distal end, and more rapidly along the margin than in the interior, a central core of the grain being left projecting as a cone into the surrounding gelatinized starch. Finally this also is gelatinized. The gelatinized grains are more swollen, have rather thin instead of thick capsules, and are much more distorted, than in *B. double light rose.*

The reaction with *chromic acid* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 60 per cent of the total starch in 30 minutes; in about 10 per cent of the grains and 87 per cent of the total starch in 45 minutes; in about 16 per cent of the grains and 92 per cent of the total starch in 60 minutes. (Chart D 506.)

Note.—The time-reactions with *B. socotrana* are much slower than those of other specimens, as has been stated. The margin of the grain remains very resistant throughout the experiment, but at about 30 minutes much of the grain becomes gelatinized and the process progresses quite rapidly until the end of the reaction. This will be more fully described in the notes on the qualitativve reactions.

A portion of the margin of many of the grains of all species is much more resistant than most of the grain, hence the percentage of gelatinization of the grains is much lower than that of the total starch. The experiment has been considered as complete when the total has reached 95 per cent or more. (See note, page 697.)

The hilum becomes as distinct as in *B. double light rose* and the lamellæ more distinct than in that starch. Gelatinization begins at the hilum which swells slightly. Two fissures which are continued as furrows extend from either side of the hilum three-fourths of the distance to the distal end, and 2 rows of slanting fissures are quickly formed in the material just distal to the hilum. The hilum swells very little and apparently no more rapidly toward the proximal than toward the distal end. The grain remains in this way without further change, except that it grows more refractive, and is gradually divided into an outer, homogeneous-looking layer and an inner fissured and granular mass. The outer layer is dissolved at one corner of the distal end, and in some grains splits away from the inner granular portion which is sometimes the last to be dissolved, but often is dissolved first.

The reaction with *pyrogallic acid* begins in a few grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; very little effect beyond a slight swelling of the hilum occurs in 15, 30, 45, and 60 minutes. (Chart D 507.)

The hilum is as distinct as in *B. double light rose,* and the lamellæ are more distinct than in that starch. Gelatinization begins at the hilum which enlarges somewhat. Two short fissures, which are not seen in *B. double light rose,* appear extending from either side of the hilum nearly half the distance to the distal margin. The starch just distal to the hilum and comprehended between these 2 fissures is divided by a double row of slanting fissures which become more distinct as the grain swells somewhat. Finally this part of the grain is gelatinized, leaving a refractive granular residue at the distal end. The starch at the proximal and distal margins and sides forms a thick, refractive, lamellated, marginal band. No further change within an hour except an increased refractivity of the whole grain. (See note, page 698.)

The reaction with *nitric acid* begins in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 27 per cent of the total starch in 5 minutes; in about 20 per cent of the grains and 80 per cent of the total starch in 15 minutes; in about 32 per cent of the grains and 88 per cent of the total starch in 30 minutes; in about 48 per cent of the grains and 95 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Charts D 509 and D 531.)

The hilum becomes very distinct in all the grains, and unlike in *B. double light rose* is unattended by the formation of a bubble in any of the grains. Gelatinization begins at the hilum which swells somewhat more toward the proximal than toward the distal end, and 2 fissures form, which extend from either side of the hilum nearly to the distal margin. The starch comprehended between these 2 fissures is first divided rather indistinctly by 2 rows of slanting fissures which become more and more distinct, and this starch is slowly gelatinized, leaving small pointed protuberances of refractive material projecting from the sides into the center of the swelling

grain. This is as far as the reaction ever seems to get except in some injured grains that can not be considered normal.

The reaction with *sulphuric acid* begins in about 15 seconds. Complete gelatinization occurs in about 80 per cent of the entire number of grains and 92 per cent of the total starch in 30 seconds; in more than 99 per cent of the grains and total starch in 45 seconds. (Chart D 510.)

The reaction with *hydrochloric acid* begins in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 8 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 10 per cent of the total starch in 30 minutes; little if any advance in 45 minutes; in about 5 per cent of the grains and 12 per cent of the total starch in 60 minutes. (Chart D 511.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in 100 per cent of the entire number of grains and total starch in 10 seconds. (Chart D 512.)

The reaction with *potassium iodide* begins in a few grains by slight swelling of the hilum in 1 minute. Very little if any change occurs with the exception of slight swelling of the hilum in most of the grains in 5, 15, 30, 45, and 60 minutes, respectively. (Chart D 513.)

The reaction with *potassium sulphocyanate* begins in a few grains in 30 seconds. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 7 per cent of the total starch in 5 minutes; in about 4 per cent of the grains and 10 per cent of the total starch in 15 minutes; in about 6 per cent of the grains and 15 per cent of the total starch in 30 minutes; in about the same percentage of grains and total starch in 45 minutes; in about the same percentage of grains and 18 per cent of the total starch in 60 minutes. (Chart D 514.)

The reaction with *potassium sulphide* begins in a few grains immediately. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 15 seconds; in about 1 per cent of the grains and 8 per cent of the total starch in 30 seconds; in about 45 per cent of the grains and 75 per cent of the total starch in 1 minute; in about 90 per cent of the grains and 99 per cent of the total starch in 5 minutes. (Chart D 515.)

The reaction with *sodium hydroxide* begins in a few grains in 30 seconds. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 54 per cent of the total starch in 5 minutes; in about 23 per cent of the grains and 68 per cent of the total starch in 15 minutes; in about 45 per cent of the grains and 75 per cent of the total starch in 30 minutes; in about 50 per cent of the grains and 81 per cent of the total starch in 45 minutes; in about 54 per cent of the grains and 84 per cent of the total starch in 60 minutes. (Chart D 516.)

The reaction with *sodium sulphide* begins in rare grains in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 6 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 7 per cent of the total starch in 30 minutes; very slight advance in 45 minutes; in about the same percentage of grains and 9 per cent of the total starch in 60 minutes. (Chart D 517.)

The reaction with *sodium salicylate* begins in 30 seconds. Complete gelatinization occurs in about 48 per cent of the grains and 61 per cent of the total starch in 3 minutes; in about 63 per cent of the grains and 75 per cent of the total starch in 5 minutes; in about 99 per cent of the grains and in more than 99 per cent of the total starch in 10 minutes. (Chart D 518.)

The reaction with *calcium nitrate* begins in very rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the entire number of grains and total starch in 15 minutes; in less than 0.5 per cent of the grains and 1 per cent of the total starch in 30 minutes; very little if any further change in 45 and 60 minutes. (Chart D 519.)

The reaction with *uranium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in less than 0.5 per cent of the grains and 10 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 17 per cent of the total starch in 30 minutes; in about 5 per cent of the grains and 22 per cent of the total starch in 45 minutes; in about 6 per cent of the grains and 25 per cent of the total starch in 60 minutes. (Chart D 520.)

The reaction with *strontium nitrate* begins in rare grains in 1 minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 10 per cent of the grains and 44 per cent of the total starch in 15 minutes; in about 31 per cent of the grains and 78 per cent of the total starch in 30 minutes; in about 47 per cent of the grains and 81 per cent of the total starch in 45 minutes; in about 56 per cent of the grains and 84 per cent of the total starch in 60 minutes. (Charts D 521 and D 532.)

The hilum and lamellæ become more distinct than in *B. double light rose*. Gelatinization begins at the hilum which swells slightly. Two fissures which are continued into furrows are seen to extend from either side of the hilum nearly to the distal margin. The starch comprehended between them is first fissured by fine longitudinal lines, and then in many grains by a double row of slanting fissures which are first seen near the hilum and then progressively nearer the distal end as the grain swells, and this starch is gelatinized from the hilum distalward. As it is gelatinized it leaves a series of refractive protuberances projecting on either side into the interior of the gelatinized grain. In most of the grains, this process does not extend quite to the distal end, a broad band of starch being left there. This is cut up by fine longitudinal fissures and is the last part of the grain to be gelatinized. The portion at the proximal end and sides, as in *B. double light rose*, forms a thick, homogeneous-looking, marginal band which is slowly gelatinized. The gelatinized grains are more swollen, do not have such thick capsules, and are more distorted, particularly at the distal end, than in *B. double light rose*.

The reaction with *cobalt nitrate* begins in very rare grains in 1 minute. Complete gelatinization is not observed in any grains in 5 minutes, and even after the grains have been treated for 15, 30, 45, and 60 minutes only rare grains are much affected by the reagent, so that complete gelatinization occurs in much less than 0.5 per cent of the entire number of grains and total starch in 60 minutes. (Chart D 522.)

The reaction with *copper nitrate* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; in less than 0.5 per cent of the grains and total starch in 15 minutes; slight advance in 30 minutes; in less than 0.5 per cent of the grains and 1 per cent of the total starch in 45 minutes; in about 0.5 per cent of the grains and 2 per cent of the total starch in 60 minutes. (Chart D 523.)

The reaction with *cupric chloride* begins in rare grains in 1 minute. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; little if any advance is observed in 15, 30, 45, and 60 minutes, respectively. (Chart D 524.)

The reaction with *barium chloride* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; little if any further advance in 15, 30, 45, and 60 minutes. (Chart D 525.)

The reaction with *mercuric chloride* begins in rare grains in 2 minutes. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and total starch in 5 minutes; little if any further advance occurs in 15, 30, 45, and 60 minutes, respectively. (Chart D 526.)

Begonia ensign (Hybrid).

(Plate 21, fig. 126; Charts D 527 to D 532.)

Histologic Properties.

In *form* the grains are always simple as in both parents, and isolated as in *B. socotrana.* They are usually as regular as in *B. double light rose,* and any irregularities are due to the same causes as in that starch, except that some grains have protuberances as in *B. socotrana.* The conspicuous forms are ovoid, elongated ovoid, elliptical, and nearly round. The additional forms are quadrilateral with much rounded angles, rod-shaped, and triangular. The grains, as in *B. double light rose,* are not flattened. In form *B. ensign* shows a closer relationship to *B. double white rose* than to *B. socotrana.*

The *hilum* is as distinct as in *B. double light rose,* and more distinct than in *B. socotrana.* It is no more often fissured than in *B. double light rose,* and the fissures have the same forms as in that starch. The hilum is never centric as it sometimes is in *B. double light rose,* but is eccentric from 0.42 to 0.16, usually 0.25, of the longitudinal axis; this is 0.06 more eccentric than in *B. double light rose,* and 0.07 less than in *B. socotrana.* In the character of the hilum, *B. ensign* shows a closer relationship to *B. double light rose,* but in the degree of eccentricity there is a somewhat closer relationship to *B. socotrana.*

The *lamellæ* are more distinct than in *B. double light rose* and have the same character and arrangement as in that grain, except that they are often wavy in outline and always more distinct at the distal than at the proximal end, as in *B. socotrana.* The number counted on the larger grains varies from 28 to 45, usually 33. In the character of the lamellæ *B. ensign* shows a somewhat closer relationship to *B. double light rose* than to *B. socotrana,* but in number the reverse.

In *size* the grains vary from the smaller which are 6 by 6μ, to the larger which are 46 by 22μ, in length and breadth. The common sizes are 28 by 16μ and 20 by 20μ. In size and proportion of the common-sized grains *B. ensign* is somewhat closer to *B. double light rose,* but in those of the larger grains closer to *B. socotrana.*

Polariscopic Properties.

The *figure* is distinct and varies from moderately to very clear-cut as in *B. socotrana.* The lines cross at an acute angle which does not vary greatly in the different grains as in *B. socotrana.* They are more often bent and bisected than in either parent, and in the first respect more closely resemble *B. double light rose* and in the last *B. socotrana.*

The *degree of polarization* varies from moderate to high (value 67), 7 units more than in *B. socotrana* and 3 units less than in *B. double light rose.* There is rarely any variation in a given aspect of an individual grain as in *B. double light rose.*

With *selenite* the quadrants are as clear-cut as in *B. socotrana.* They are less unequal in size than in *B. socotrana,* but more than in *B. double light rose;* and are more irregular in size than in either parent, but in this respect more closely resemble *B. double light rose* than *B. socotrana.* The colors as in *B. double light rose* are usually pure, but a somewhat smaller number of grains have a greenish tinge.

In the character of the figure *B. ensign* shows a closer relationship to *B. socotrana,* and in the degree of polarization and the appearances with selenite to *B. double light rose.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a light to moderate blue-violet (value 40), 5 units less than in *B. double light rose* and 10 units more than in *B. socotrana.* With 0.125 per cent Lugol's solution the grains all color a light blue-violet, less than *B. double light rose,* but much more than in *B. socotrana.* After heating in water until the grains are all gelatinized, and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* are usually colored moderately light, a few light, and a few a deep indigo as in *B. double light rose;* and the *solution* a deep indigo as in *B. double light rose.* If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the *grain-residues* all color a light to moderate indigo at the proximal end, the *capsules* a deep violet, and the *solution* a very deep indigo, as in *B. double light rose.* Qualitatively and quantitatively the reactions with iodine show a closer relationship to *B. double light rose* than to *B. socotrana.*

Aniline Reactions.

With *gentian violet* the grains all color lightly at once, and in 30 minutes they are light to moderately colored (value 30), 5 units less than in *B. socotrana* and 10 units less than in *B. double light rose;* the greater num-

ber of the grains are lightly colored, a few very lightly, a few moderately, and some grains deeply.

With *safranin* the grains all color lightly at once, and in 30 minutes they are moderately to deeply colored (value 50), 5 units less than in *B. socotrana* and 10 units less than in *B. double light rose.* The majority of the grains are colored moderately, a few moderately to lightly, and a few deeply.

In the reactions with aniline stains *B. ensign* shows a closer relationship to *B. socotrana* than to *B. double light rose.*

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 64° to 65.5° C., and of all 66° to 68° C., mean 67° C. The mean is 4° C. higher than in *B. double light rose* and 14.4° C. lower than in *B. socotrana.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 75 per cent of the entire number of grains and 89 per cent of the total starch in 5 minutes; in about 98 per cent of the grains and 99 per cent of the total starch in 10 minutes. (Chart D 527.)

The hilum is indistinct as in *B. double light rose.* The lamellæ are invisible as in both parents. The grains become somewhat more refractive after the addition of the reagent and the first part of the grain to be so affected is a narrow band at the margin which is as refractive as in *B. double light rose.* Gelatinization begins at the distal margin and proceeds as in *B. double light rose* except that in no case is gelatinization preceded by a pitted appearance of the ungelatinized starch, in this respect resembling *B. socotrana.* The gelatinized grains are as much swollen and have nearly as thick capsules as in *B. double light rose,* and are nearly as much distorted as in *B. socotrana.* In this reaction *B. ensign* shows qualitatively a somewhat closer relationship to *B. double light rose* than to *B. socotrana.*

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 12 per cent of the entire number of grains and 50 per cent of the total starch in 5 minutes; in about 21 per cent of the grains and 88 per cent of the total starch in 15 minutes; in about 63 per cent of the grains and 98 per cent of the total starch in 30 minutes. (Chart D 528.) (See pages 697 and 705.)

The hilum and lamellæ are as distinct as in *B. socotrana.* Gelatinization begins at the hilum as in both parents, but progresses as in *B. double light rose,* except that the inner mass of starch remains less gelatinized and more granular before solution, showing the influence of *B. socotrana.*

The reaction with *pyrogallic acid* begins in a few grains in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 12 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 30 per cent of the total starch in 15 minutes; in about 33 per cent of the grains and 53 per cent of the total starch in 30 minutes; in about 35 per cent of the grains and 65 per cent of the total starch in 45 minutes; in about 47 per cent of the grains and 71 per cent of the total starch in 60 minutes. (Chart D 529.)

The hilum and lamellæ are as distinct as in *B. socotrana.* Gelatinization begins at the hilum and progresses as in *B. double light rose,* except that in some grains an indistinct double row of slanting fissures may be seen just distal to the hilum, showing the influence of *B. socotrana.* The gelatinized grains are as much swollen, have somewhat thicker capsules (if they ever become completely gelatinized, which is to be doubted in many grains), and are not so much distorted as in that starch.

In this reaction *B. ensign* shows qualitatively a closer relationship to *B. double light rose* than to *B. socotrana.* (See note, page 698.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 80 per cent of the entire number of grains and 88 per cent of the total starch in 15 seconds; in more than 99 per cent of the grains and total starch in 30 seconds. (Chart D 531.)

The hilum, as in *B. double light rose,* becomes distinct in all the grains, attended by the formation of a bubble in a majority. The lamellæ are as distinct as in *B. socotrana.* Gelatinization begins at the hilum and progresses as in *B. double light rose.* The gelatinized grains are as much swollen as in *B. double light rose,* but the capsules are not so thick, and they are more distorted at the distal end than in that starch. In this reaction *B. ensign* shows qualitatively a closer relationship to *B. double light rose* than to *B. socotrana.*

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 10 per cent of the entire number of grains and 26 per cent of the total starch in 1 minute; in about 78 per cent of the grains and 91 per cent of the total starch in 2 minutes; in about 95 per cent of the grains and 99 per cent of the total starch in 3 minutes. (Chart D 532.)

The hilum and lamellæ are as distinct as in *B. socotrana.* Gelatinization begins at the hilum and proceeds as in *B. double light rose,* except that 2 fissures proceeding from either side of the hilum are formed in more grains than in that starch, and in some grains a double row of rather indistinct slanting fissures is formed as in *B. socotrana.* The gelatinized grains are as much swollen, have as thick capsules, and are as much distorted as in *B. double light rose.* In this reaction *B. ensign* shows qualitatively a closer relationship to *B. double light rose* than to *B. socotrana.*

38. Starches of Begonia double white, B. socotrana, and B. julius.

Starch of *Begonia socotrana* (pollen parent) is described on pages 704 to 707.

Begonia double white (Seed Parent).

(Plate 22, fig. 127; Charts D 533 to D 538.)

Histologic Properties.

In *form* the grains are almost solely simple and isolated, only occasionally compound grains and aggregates are seen. The compound grains are always of one type: 2 small grains, each consisting of a hilum and 1 or 2 lamellæ, surrounded by 30 or more secondary lamellæ and located at the proximal end of a large elongated grain. The aggregates consist of 2, 3, or 4 small grains or of 2 small grains adhering to the distal end of a somewhat larger one. The grains are usually regular,

and any irregularities that may occur are due to the following causes: (1) A secondary set of lamellæ whose longitudinal axis is usually at a right angle to that of the primary set; (2) rarely, 1 or 2 rounded protuberances from the proximal end; (3) 1 or 2 pressure facets on the smaller grains; (4) rarely, a slight deviation of the axis and consequent bending of the grain. The conspicuous forms are ovoid, elongated elliptical, round and nearly round, and triangular. The additional forms are dome-shaped and pyriform. The grains are usually not flattened, but the few broad forms are somewhat flattened and when seen on edge have an elongated elliptical or ovoid shape.

The *hilum* when not fissured is a rather indistinct, small, round spot. It is fissured in a small majority of the grains and the fissures are very small and not deep. They have the following forms: (1) A small, straight, transverse or oblique line; (2) cruciate, T- or Y-forms; (3) an irregularly stellate arrangement or fissures; (4) a flying-bird. The hilum is eccentric from 0.44 to 0.12, usually 0.25, of the longitudinal axis.

The *lamellæ* are usually fine, regular, and moderately distinct. Near the hilum, they are round or oval in form and continuous, and in the rest of the grain, down to the margin, they are regular but discontinuous and have the form of the outline of the grain. There is often 1 broad refractive lamella near the hilum and, if the grain contains both primary and secondary starch, broad refractive lamellæ surrounding the primary grain; while there are often 3 or 4 other coarse lamellæ from about the upper one-third to the margin which divide the fine lamellæ into bands of varying breadth. The lamellæ of the secondary starch are not so fine and are more distinct than those of the primary deposit. The number counted on the larger grains varies from 18 to 40, usually 36, less than in *B. socotrana.*

In *size* the grains vary from the smaller which are 4 by 4μ, to the larger which are 44 by 24μ, rarely 50 by 26μ, in length and breadth. The common sizes are 22 by 18μ and 24 by 14μ.

Comparison of the *histologic properties* between *B. socotrana* and *B. double white* shows:

Form:—Compound grains and aggregates which occur occasionally in *B. double white* are not seen at all in *B. socotrana.* The grains of *B. socotrana* are more irregular than those of *B. double white,* and the irregularities are due to the following causes: (1) 1 or more large rounded protuberances from the proximal end and sides; (2) a greater development of one part of the distal end than the rest; (3) a deviation of the axis and consequent bending of the grain; (4) rarely, regular elevations and depressions in the distal end producing a fluted appearance; (5) rarely, a secondary set of lamellæ whose longitudinal axis is at an angle to that of the primary set. The first of these causes is but rarely seen in *B. double white,* the second and fourth are never seen, and the fifth (which occurs but rarely in *B. socotrana*) is the most common cause of irregularity in *B. double white.* In form the grains are much more often elongated, comparatively few of the round or triangular forms being seen.

The *hilum* is somewhat less distinct and is much less often fissured. The fissures have only three forms: (1) As in *B. double white,* a single, straight, rarely curved line, transversely or obliquely placed; (2) a somewhat branched Y form, but no cruciate or T forms such as occur in *B. double white* are seen; (3) as in *B. double white,* an irregularly stellate arrangement of fissures. The hilum usually is 0.18 of the longitudinal axis, which is 0.07 more eccentric than in *B. double white.*

The *lamellæ* are not so distinct and are usually finer than in *B. double white.* There is never a broad, distinct lamella very near the hilum, nor a distinct lamella separating the primary from the secondary starch in grains which consist of both primary and secondary starch. Otherwise the arrangement is the same. They are often not regular, as in *B. double white,* but show a waviness of outline.

In *size* the grains are somewhat larger and more slender, the larger grains being 2μ longer and 2μ narrower than the largest grain measured in *B. double white.* The common sizes are, respectively, 8μ longer and the same breadth, and 8μ longer and 3μ broader, than the corresponding common sizes of *B. double white.*

Polariscopic Properties.

The *figure* is distinct and moderately well-defined. The lines are fine, as a rule, and cross at a right angle or at an acute angle which varies somewhat in size in the different grains. They are often somewhat bent and moderately often bisected.

The *degree of polarization* varies from low to moderately high (value 55). In most grains it is moderate, in a few it is low, and in a few moderately high. There is often some variation in a given aspect of an individual grain.

With *selenite* the quadrants are moderately clear-cut. They are usually unequal in size and often irregular in shape. The colors are usually not quite pure.

Comparison of the *polariscopic properties* between *B. socotrana* and *B. double white* shows:

The *figure* is as distinct and usually better defined. The lines are not so fine and usually cross at an acute angle which does not vary so greatly in size in different grains. They are less often bent or bisected than in *B. double white.*

The *degree of polarization* varies from moderate to moderately high (value 60), 5 units more than in *B. double white.* There is less often variation in a given aspect of an individual grain.

With *selenite* the quadrants are more clear-cut, they are more unequal in size, and more regular in shape than in *B. double white.* The colors are more often pure and there are some which show a greenish tinge.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a light violet (value 25). The color deepens slowly until it is moderately deep and has assumed a somewhat bluish tint. With 0.125 per cent Lugol's solution the grains all color very lightly, and the color deepens slowly until it is moderate and has assumed a somewhat bluish tint. After heating in water until the grains are all gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* are all colored a moderate indigo, and the *solution* a deep indigo. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the *grain-residues*

are all colored a light to moderate indigo; the *capsules* a moderate violet, and the *solution* a very deep indigo.

Comparison of the *iodine reactions* between *B. socotrana* and *B. double white* shows:

With 0.25 per cent Lugol's solution the grains all color a light to moderate violet tinged with blue (value 30), 5 units more than in *B. double white*. With 0.125 per cent Lugol's solution the grains all color a very light violet, more than in *B. double white*. After heating in water until the grains are all gelatinized and then treating with a 2 per cent Lugol's solution the gelatinized grains all color more and the solution less than in *B. double white*. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution the grain-residues are all colored more, the capsules a deeper violet, and the solution the same as in *B. double white*.

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes they are lightly colored (value 30). Most of the grains are colored lightly, a few very lightly, and a few moderately colored.

With *safranin* the grains all color very lightly at once, and in 30 minutes they are lightly to moderately colored (value 40), 10 units more than with gentian violet. Most of the grains are colored lightly to moderately, some lightly, and a very few deeply.

Comparison of the *aniline reactions* between *B. socotrana* and *B. double white* shows:

With *gentian violet* the grains are light to moderately colored (value 35), 5 units more than *B. double white*. There are a few grains which are deeply colored.

With *safranin* the grains are moderately colored (value 55), 15 units more than with *B. double white*. More grains are colored deeply to moderately deeply than in that starch.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 60° to 61.5° C., and of all 65° to 66.5° C., the mean is 65.75° C.

Comparison of the *temperature reactions* between *B. socotrana* and *B. double white* shows:

The temperature of gelatinization of all the grains of *B. socotrana* is 81° to 81.8° C., mean 81.4° C., which is 15.65° C. more than that of *B. double white*.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 76 per cent of the entire number of grains and 83 per cent of the total starch in 5 minutes; in about 99 per cent of the grains and more than 99 per cent of the total starch in 10 minutes. (Chart D 533.)

The hilum becomes rather indistinct in all the grains, unattended by the formation of a bubble in any. The lamellæ are not visible. The grain becomes more refractive after the addition of the reagent, and the first part of the grain to show this is a rather narrow band at the margin which, however, does not become very refractive. Gelatinization begins at the distal margin and proceeds rather irregularly to the hilum, preceded by short cracks which invade the ungelatinized starch just before gelatinization. It usually proceeds more rapidly along the margin than in the interior of the grain, and the proximal margin is gelatinized before the starch immediately around the hilum, which is, however, not split when the hilum swells, but gelatinizes rapidly as one piece. The gelatinized grains are much swollen, have rather thick capsules, and are much distorted.

Comparison of the *chloral-hydrate* reactions between *B. socotrana* and *B. double white* shows:

The hilum and lamellæ are both invisible. Gelatinization in the majority of the grains begins at the distal end and from there proceeds to the hilum and proximal end. In a moderate minority the proximal end is gelatinized soon after the distal end, and the most resistant part of the grain is midway between the hilum and the distal end. This method is not seen in *B. double white*. In the first method the differences noted are that gelatinization proceeds smoothly without any preliminary cracking of the ungelatinized starch as in *B. double white*, and that the portion at the proximal margin is the last to be gelatinized instead of that immediately surrounding the hilum. The gelatinized grains are as much swollen, and as much distorted, as in *B. double white* but the capsules are rather thin instead of thick.

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 75 per cent of the entire number of grains and 97 per cent of the total starch in 5 minutes; in about 86 per cent of the grains and 99 per cent of the total starch in 15 minutes. (Chart D 534.) (See pages 697 and 705.)

The hilum becomes distinct, unattended by the formation of a bubble in any of the grains. The lamellæ are distinct in some grains and not visible in others. Gelatinization begins at the hilum which swells much more rapidly toward the proximal end than toward the distal end. Two fissures are formed which extend from either side of the hilum one-half to three-fourths of the distance between the hilum and the margin. The starch comprehended between these fissures becomes indistinctly granular and is gelatinized very rapidly, leaving in some grains a small refractive mass at the distal end, but in the majority only a marginal band which is broader at the distal than at the proximal end. The capsule is then dissolved at the proximal end and solution proceeds toward the distal which is the last to be dissolved. In some grains there is a separation of the marginal band into 2 layers which dissolve independently.

Comparison of the *chromic-acid* reactions between *B. socotrana* and *B. double white* shows:

The hilum and lamellæ are somewhat more distinct than in *B. double white*. Gelatinization begins at the hilum which swells slightly, but not so rapidly as in *B. double white* nor so much toward the proximal end. The other differences noted are that the starch comprehended between the 2 fissures from the hilum is formed into an inner granular mass which is easily differentiated from the outer layer. This outer marginal layer is finally dissolved at one corner of the distal margin, and separated from the inner granular portion which may be dissolved first or last.

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 42 per cent of the grains and 84 per cent of the total starch in 5 minutes; in about 62 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 73 per

cent of the grains and 99 per cent of the total starch in 30 minutes. (Charts D 535 and D 536.) A portion of the margin of some grains is quite resistant, but most of the grain is easily gelatinized.

The hilum becomes distinct in all the grains, attended by the formation of a bubble in a moderate minority of the grains. The lamellæ are not very distinct. Gelatinization begins at the hilum which swells more rapidly toward the proximal than toward the distal end. Two fissures appear which extend from either side of the hilum one-half to three-fourths of the distance from the hilum to the distal margin, and in most grains the starch comprehended between these fissures and immediately distal to the hilum is divided by a double row of slanting fissures and then gelatinized, leaving a granular refractive residue at the distal end. In the other grains the starch between the fissures is not divided by fissures but gelatinizes rapidly, leaving also a small granular refractive mass at the distal end. The starch at the proximal and distal margins and the sides forms a thick, refractive, homogeneous band which is slowly gelatinized. The gelatinized grains are moderately swollen, have rather thick capsules, and are usually not much distorted, but sometimes vary considerably.

Comparison of the *pyrogallic-acid* reactions between *B. socotrana* and *B. double white* shows:

The hilum becomes distinct, unattended by the formation of a bubble in any of the grains. The lamellæ are more distinct than in *B. double white.* Gelatinization begins at the hilum, and the differences noted are that the starch comprehended between the 2 fissures from the hilum (and immediately distal to the hilum) is divided by a double row of slanting fissures, which are more distinct than in *B. double white,* and then slowly gelatinize, leaving a more distinctly granular and more refractive mass at the distal end than in *B. double white.* No further change takes place in the grain except an increased refractivity. (See note, page 322.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in 100 per cent of the entire number of grains and total starch in 15 seconds. (Chart D 537.)

The hilum becomes distinct in all the grains, attended by the formation of a bubble in the majority. The lamellæ are not visible. Gelatinization begins at the hilum which swells very rapidly in the direction of the proximal end. Two fissures extend a short distance from either side of the hilum toward the distal end. The starch between is not distinctly fissured, but becomes granular and gelatinizes comparatively slowly. At the same time the bubble swells, then shrinks, and finally disappears, accompanied by considerable invagination of the capsule at the sides of the proximal end. The gelatinized grains are much swollen, have rather thin capsules, and are somewhat distorted.

Comparison of the *nitric-acid* reactions between *B. socotrana* and *B. double white* shows:

The hilum becomes distinct in all the grains unattended by the formation of a bubble in any. The lamellæ are also distinct. The hilum does not enlarge so much toward the proximal end as in *B. double white,* and the starch comprehended between the 2 fissures which extend from either side of the hilum nearly to the margin is divided by 2 rows of slanting fissures and is then slowly gelatinized, leaving small pointed protuberances of refractive starch projecting into the interior of the swelling grain. This is as far as the reaction ever goes in the normal grains, and none of these phenomena is seen in *B. double white.*

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 92 per cent of the entire number of grains and 97 per cent of the total starch in 1 minute; in 100 per cent of the grains and total starch in 2 minutes. (Chart D 538.)

The hilum becomes distinct in all the grains, attended by the formation of a bubble in a few. The lamellæ are moderately distinct in some grains, but in the majority they are not visible. Gelatinization begins at the hilum which swells rapidly, more rapidly toward the proximal than toward the distal end. Two indistinct fissures extend from either side of the hilum nearly to the distal margin, and the starch comprehended between them is fissured by rather indistinct longitudinal fissures. This is gelatinized with moderate rapidity and leaves a small refractive granular residue at the distal margin. The starch at the proximal end and sides forms a homogeneous-looking, refractive, marginal band which is much thicker and broader at the sides than at the proximal end. This grows thinner and more nearly transparent and is finally gelatinized as is also the irregular refractive mass at the distal end. The gelatinized grains are much swollen, have thick capsules, and are somewhat distorted.

Comparison of the *strontium-nitrate* reactions between *B. socotrana* and *B. double white* shows:

The hilum becomes distinct in all the grains, unattended by the formation of a bubble in any. The lamellæ are always visible and are more distinct than in *B. double white.* Gelatinization proceeds in very much the same manner as in *B. double white,* except that the 2 fissures which extend from either side of the hilum are more distinct, as are also the longitudinal fissures in the starch comprehended between them. This starch is also often divided by a double row of slanting fissures which are first seen near the hilum and then progressively nearer the distal end as the grain swells and the portion near the hilum is gelatinized. The gelatinized grains are more swollen, do not have such thick capsules, and are more distorted, particularly at the distal end, than in *B. double white.*

Begonia julius (Hybrid).

(Plate 22, fig. 129; Charts D 533 to D 538.)

Histologic Properties.

In *form* the grains are usually simple and isolated, but, as in *B. double white,* compound grains and aggregates are occasionally seen. They both are of the same types as in *B. double white.* The grains are usually regular, and have fewer irregularities than in either parent, in this characteristic showing a closer relationship to *B. double white* than to *B. socotrana.* The irregularities which occur are due to the following causes: (1) Slight deviation of the longitudinal axis and consequent bending of the grain; (2) 1 or 2 large or small, rounded protuberances from the proximal end or sides; (3) rarely, depressions and elevations of the distal end and margin

of the grain, sometimes giving an irregularly fluted appearance; (4) a secondary set of lamellæ whose longitudinal axis is at an angle with that of the primary set; (5) a greater development of one end or of one side of the grain than the rest. The character of the irregularities is closer to that of *B. socotrana* than to *B. double white.* The conspicuous forms are elongated and short elliptical with flattened distal end, round, nearly round. The additional forms are triangular, ovoid, quadrilateral with rounded angles, dome-shaped, and rod-shaped. The broad forms are somewhat flattened as in both parents. In form *B. julius* shows a somewhat closer relationship to *B. socotrana* than to *B. double white.*

The *hilum* is not very distinct and is rarely fissured as in *B. socotrana.* The fissures have the following forms: (1) A single, short, straight line transversely or obliquely placed; (2) an irregularly stellate arrangement of fissures. The hilum is eccentric from 0.4 to 0.15, usually 0.2, of the longitudinal axis, which is 0.02 less eccentric than in *B. socotrana* and 0.05 more eccentric than in *B. double white.* In the character and the eccentricity of the hilum *B. julius* shows a closer relationship to *B. socotrana* than to *B. double white.*

The *lamellæ* are as distinct as in *B. socotrana* and not so distinct as in *B. double white,* but otherwise have the same character and arrangement as in *B. double white.* The number counted on the larger grains varies from 20 to 40, usually 36, the same as in *B. double white,* and slightly more than in *B. socotrana.*

In the character and arrangement of the lamellæ *B. julius* shows a somewhat closer relationship to *B. double white* than to *B. socotrana.*

In *size* the grains vary from the smaller which are 4 by 4μ, to the larger which are 48 by 24μ, in length and breadth. The common size is 24 by 14μ, which is 8μ shorter and the same breadth as in *B. socotrana* and the same length and breadth as in the elongated common forms of *B. double white.*

In size *B. julius* shows a closer relationship to *B. double white,* and in proportion to *B. socotrana.*

Polariscopic Properties.

The *figure* is as distinct and as well defined as in *B. socotrana.* The lines are not so thick as in that starch, but not so thin as in *B. double white.* They cross at a right angle or at an acute angle which does not vary greatly in size in the different grains as in *B. socotrana.* They are as much bent and bisected as in *B. double white.*

The *degree of polarization* varies from moderate to moderately high (value 60), the same as in *B. socotrana* and 5 units more than in *B. double white.* There is but little variation in a given aspect of the individual grains.

With *selenite* the quadrants are as clear-cut as in *B. socotrana.* They are not so unequal in size and are more irregular in shape than in that starch, but the same as in *B. double white.* The colors are as pure as in *B. socotrana.*

In the character of the figure the hybrid resembles both parents equally, but in different respects. In the degree of polarization and the appearances with selenite it shows a closer relationship to *B. socotrana* than to *B. double white.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a light to moderate violet (value 40), 10 units more than *B. socotrana* and 15 units more than in *B. double white.* With 0.125 per cent Lugol's solution the grains are colored a light violet, more than in *B. socotrana* and much more than in *B. double white.* After heating in water until all the grains are completely gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* all color a moderate indigo and the *solution* a deep indigo as in *B. double white.* If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, a small majority only of the *grain-residues* color a light indigo, less than in *B. double white* and much less than in *B. socotrana;* the *capsules* a moderate violet, and the *solution* a very deep indigo as in *B. double white.* Qualitatively and quantitatively the iodine reactions with the unheated grains are closer to those of *B. socotrana* than *B. double white,* but with the grains heated in water they are closer to *B. double white* than to *B. socotrana.*

Aniline Reactions.

With *gentian violet* the grains all color lightly at once, and in 30 minutes they are lightly to moderately or deeply colored (value 45), 10 units more than in *B. socotrana* and 15 units more than in *B. double white.*

With *safranin* the grains all color lightly at once, and in 30 minutes they are moderately deeply colored (value 60), 5 units more than in *B. socotrana* and 10 units more than in *B. double white.*

In the reactions with aniline stains *B. julius* shows a closer relationship to *B. socotrana* than to *B. double white.*

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 65° to 66° C., and of all is 67° to 69° C., mean 68° C., which is 5.25° C. higher than that of *B. double white* and 13.4° C. lower than in *B. socotrana.* The temperature of gelatinization of *B. julius* is closer to that of *B. double white* than that of *B. socotrana.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 80 per cent of the entire number of grains and 90 per cent of the total starch in 5 minutes; in more than 99 per cent of both the grains and total starch in 10 minutes. (Chart D 533.)

The hilum is more distinct than in either parent, in this respect more closely resembling *B. double white* than *B. socotrana.* The lamellæ are invisible, as in both parents. The grains become more refractive after the addition of the reagent, and the first part of the grain to show this change is a rather narrow band at the margin which is as narrow and no more refractive than in *B. double white.* Gelatinization begins at the corners of the distal margin and proceeds in most grains as in *B. double white,* but in some according to the method described for the majority of the grains of *B. socotrana.* The gelatinized grains are much swollen, have as thin capsules as in *B. socotrana,* and are as much distorted as in both parents. In this reaction *B. julius* shows qualitatively a somewhat closer relationship to *B. double white* than to *B. socotrana.*

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in 7 per cent of the entire number of grains and 75 per cent of the total starch in 5 minutes; in about 41 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 95 per cent of the grains and 99 per cent of the total starch in 30 minutes. (Chart D 534.) (See pages 697 and 705.)

The hilum and lamellæ are as distinct as in *B. socotrana.* Gelatinization begins at the hilum and progresses as in *B. double white,* except that the starch between the 2 fissures, which proceed from the hilum, is more distinctly fissured and becomes more distinctly granular, showing the influence of *B. socotrana.* There is not a clearly marked division into an outer and an inner layer as in either parent, and in this respect the hybrid more closely resembles *B. double white.* In this reaction *B. julius* shows qualitatively a somewhat closer relationship to *B. double white* than to *B. socotrana.*

The reaction with *pyrogallic acid* begins in rare grains in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 20 per cent of the total starch in 5 minutes; in about 7 per cent of the grains and 75 per cent of the total starch in 15 minutes; in about 44 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 58 per cent of the grains and 92 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 95 per cent of the total starch in 60 minutes. (Chart D 535.)

The hilum and lamellæ are as distinct as in *B. socotrana,* and gelatinization proceeds as in *B. double white,* except that the starch just distal to the hilum and comprehended between the 2 fissures from either side of the hilum is less often divided by a double row of slanting fissures, and more often simply gelatinizes without any distinct fissuring or granule formation. The gelatinized grains are moderately swollen, and have rather thick capsules as in *B. double white,* but are somewhat more distorted than in that starch. In this reaction *B. julius* shows qualitatively a closer relationship to *B. double white* than to *B. socotrana.* (See note, page 698.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 95 per cent of the entire number of grains and 99 per cent of the total starch in 15 seconds; in 100 per cent of the grains and total starch in 30 seconds. (Chart D 537.)

The hilum and lamellæ are as distinct as in *B. socotrana.* Gelatinization begins at the hilum and progresses as in *B. double white.* The gelatinized grains are as much swollen, and have as thin capsules as in *B. double white,* but are somewhat more distorted than in that starch. In this reaction *B. julius* shows qualitatively a closer relationship to *B. double white* than to *B. socotrana.*

The reaction with *strontium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 68 per cent of the entire number of grains and 84 per cent of the total starch in 1 minute; in about 96 per cent of the grains and 99 per cent of the total starch in 2 minutes. (Chart D 538.)

The hilum and lamellæ are as distinct as in *B. socotrana.* Gelatinization begins at the hilum and progresses in the great majority of the grains as in *B. double white,* but in some grains a double row of slanting fissures is formed as in *B. socotrana* and gelatinization progresses as in that starch. The gelatinized grains are as much swollen, have as thick capsules, and are as much distorted as in *B. double white.* In this reaction *B. julius* shows, qualitatively, a closer relationship to *B. double white* than to *B. socotrana.*

39. Starches of Begonia double deep rose, B. socotrana, and B. success.

Starch of *Begonia socotrana* (pollen parent) is described on pages 704 to 707.

Begonia double deep rose (Seed Parent).

(Plate 22, fig. 130; Charts D 539 to D 544.)

Histologic Properties.

In *form* the grains are usually simple and isolated. A few compound grains are seen, and also a number of small single grains with pressure facets on their distal ends, indicating the previous existence of aggregates. The compound grains belong to two types: (1) 2 grains, each consisting of a hilum and 3 or 4 lamellæ, surrounded by 2 to 3 common secondary lamellæ, and located at the middle of a common-sized grain; (2) 2 grains each consisting of a hilum and 1 or 2 lamellæ surrounded by 12 to 18 common secondary lamellæ and attached to the proximal end of a somewhat elongated grain. A small majority of the grains are somewhat irregular, and the irregularities are due to the following causes: (1) A secondary set of lamellæ whose longitudinal axis is at an angle of varying size with that of the primary set. Sometimes, some at least of the secondary lamellæ completely encircle the primary grain, and in other grains they are merely applied to one side of the primary grain; (2) wide, shallow depressions in the margin; (3) small rounded protuberances from the sides or from either end; (4) 1 or 2 pressure facets at the distal end; (5) a slight deviation of the axis with a consequent bending of the grain. The conspicuous forms are ovoid, round, and nearly round. The additional forms are triangular, reniform, dome-shaped, quadrilateral, and lenticular. The broader grains are somewhat flattened and when seen on edge have an elongated elliptical or ovoid form.

The *hilum* is not a very distinct, small, round spot. It is very rarely fissured, and the fissures have the following forms: (1) A very small, straight, transverse line; (2) an irregularly stellate arrangement of short fissures. The hilum is eccentric from 0.42 to 0.21, usually 0.26, of the longitudinal axis.

The *lamellæ* are usually very distinct and rather coarse. Those near the hilum are not so distinct and not so coarse as those near the distal end, and those composing the primary grains are not so distinct nor so coarse as those composing the secondary starch. Near the hilum they are round and continuous, and throughout the rest of the grain they have in general the form of the outline of the grain, but are often wavy. There is usually 1 broad, very refractive lamella near the hilum. If the grain contains both primary and secondary starch the two deposits are separated by a broad refractive lamella. The number counted on the larger grains varies from 16 to 30, usually 22, much less than in *B. socotrana.*

In *size* the grains vary from the smaller which are 10 by 10μ, to the larger elongated grains which are 34 by 24μ, and the larger broader grains which are 30 by

26μ, in length and breadth. The common sizes are 24 by 18μ and 20 by 19μ.

Comparison of the *histologic properties* between *B. socotrana* and *B. double deep rose* shows:

Form: Compound grains which are sometimes seen in *B. double deep rose* do not occur in *B. socotrana,* nor are there any evidences of the existence of aggregates as in *B. double deep rose.* The grains are more regular in form than those of *B. double deep rose,* but when irregularities occur they are more striking and more obvious than in that starch. The irregularities are due to the following causes, of which the first, second, and third are more common than in *B. double deep rose,* and the fourth and fifth much less common: (1) 1, 2, or more large, rounded or pointed protuberances from the proximal end or sides; (2) a greater development of one part of the distal end of the grain than of the rest; (3) a deviation of the axis and a consequent bending of the grain; (4) elevations and depressions of the margin, especially at the distal end; (5) rarely a secondary set of lamellæ whose axis is at an angle with that of the primary set. The grains are much more elongated in form than in *B. double deep rose,* and the round or nearly round forms so common in that starch are very rare in *B. socotrana.*

The *hilum* is as distinct as in *B. double deep rose* and somewhat less rarely fissured. The fissures have the same forms as described under *B. double deep rose* and in addition a somewhat branched Y-form. The hilum is usually eccentric, 0.18 of the longitudinal axis, which is 0.08 more eccentric than is usual in *B. double deep rose.*

The *lamellæ* are fine instead of somewhat coarse and are not so distinct as in *B. double deep rose.* There is usually not a broad refractive lamella near the hilum as in *B. double deep rose,* but there are often 1 to 3 or more broad, refractive lamellæ which may be situated about half the distance from the hilum to the margin and which, in some grains, form a band at this point, but in others are separated and divide the fine lamellæ into bands of varying breadth. The lamellæ are much less numerous than in *B. double deep rose.*

In *size* the grains are commonly 30μ by 21μ and 32μ by 14μ, in length and breadth. These sizes are, respectively, 10μ longer and 2μ broader, and 6μ longer and 4μ narrower, than the corresponding common sizes of *B. double deep rose.* The larger grains also are 18μ longer and 2μ broader than the elongated grains of *B. double deep rose.*

Polariscopic Properties.

The *figure* is moderately distinct and usually well defined. The lines cross at an acute angle which varies widely in size in the different grains. They are often very much bent and moderately often are bisected. The figure may have one or more extra lines, and there are a number of multiple figures.

The *degree of polarization* varies from moderately low to high (value 50). In most of the grains it is moderate, in a few moderately low, and in a few moderately high to high. There is often considerable variation in a given aspect of an individual grain.

With *selenite* the quadrants are usually moderately clear-cut. They are unequal in size and often very irregular in shape. The colors are usually not quite pure.

Comparison of the *polariscopic properties* between *B. socotrana* and *B. double deep rose* shows:

The *figure* is more distinct and more often well defined than in *B. double deep rose.* The lines cross at an acute angle which does not vary widely in different grains, and they are much less often bent or bisected. The figure never has one or more extra lines, and multiple figures are rare.

The *degree of polarization* varies from moderate to high (value 60), 10 units more than in *B. double deep rose.* There is very little variation in a given aspect of the individual grains.

With *selenite* the quadrants are more clear-cut, and are more often regular than in *B. double deep rose.* The colors are much more often pure than in that starch.

Iodine Reactions.

With 0.25 per cent Lugol's solution, the grains all color a moderate blue-violet (value 45). The color deepens rapidly until it is very deep and has assumed a more bluish tint. With 0.125 per cent Lugol's solution the grains all color a light violet tinged with blue and the color deepens moderately rapidly until it is deep and has assumed a more bluish tint. After heating in water until all the grains are completely gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* are all colored a moderate indigo, and the *solution* a deep indigo. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the *grain-residues* are very lightly to moderately lightly colored at the proximal end, the *capsules* a moderate violet, and the *solution* a very deep indigo.

Comparison of the *iodine reactions* between *B. socotrana* and *B. double deep rose* shows:

With 0.25 per cent Lugol's solution the grains all color a light to moderate violet tinged with blue (value 30), 15 units less than in *B. double deep rose.* With 0.125 per cent Lugol's solution the grains are all very lightly colored, much less than in *B. double deep rose.* After heating in water until the grains are all gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized grains are colored a moderately light to deep indigo, more than in *B. double deep rose;* and the solution a deep indigo, less than in *B. double deep rose.* If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the grain-residues are all colored a moderate indigo at their proximal ends, more than in *B. double deep rose;* the capsules a very deep violet, more than in *B. double deep rose;* and the solution a very deep indigo the same as in *B. double deep rose.*

Aniline Reactions.

With *gentian violet* the grains color very lightly at once, and in 30 minutes they are light to moderately colored (value 40). The majority of the grains are lightly to moderately colored, a few lightly, and a very few deeply.

With *safranin* the grains all color very lightly at once, and in 30 minutes they are moderate to deeply colored (value 60). The majority of the grains are moderate to deeply colored, a few lightly, and a few deeply.

Comparison of the *aniline reactions* between *B. socotrana* and *B. double deep rose* shows:

With *gentian violet* the grains are lightly to moderately colored (value 35), 5 units less than in *B. double deep rose*. There is as much variation in depth of color in the different grains as in that starch.

With *safranin* the grains are moderately colored (value 55), 5 units less than in *B. double deep rose*. There is the same amount of variation in depth of color in the different grains as in that starch.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 64° to 65.5° C., and of all 67° to 68.8° C., mean 67.8° C.

Comparison of the *temperature reactions* between *B. socotrana* and *B. double deep rose* shows:

The temperature of gelatinization is 81° to 81.8° C., mean 81.4° C., which is 13.6° C. higher than that of *B. double deep rose*.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 96 per cent of the entire number of grains and 98 per cent of the total starch in 5 minutes. (Chart D 539.)

The hilum becomes moderately distinct in all the grains, attended by the formation of a bubble in a majority of the grains. The lamellæ are never visible. The grains become more refractive after the addition of the reagent, and the first part of the grain to show this change is a rather narrow band of starch around the margin which is quite refractive. Gelatinization begins first at discrete points at the distal end, and in the majority of the grains immediately afterwards at the proximal end. Gelatinization advances smoothly from these two points and the last portion of the grain to be gelatinized is that immediately distal to the hilum. This is usually split into two parts which gelatinize independently of one another. In a minority of the grains gelatinization occurs at the distal end only and proceeds smoothly from this point to the proximal end which is the last part of the grain to be gelatinized. The gelatinized grains are moderately swollen, have rather thick capsules, and are considerably distorted.

Comparison of the *chloral-hydrate* reactions between *B. socotrana* and *B. double deep rose* shows:

The hilum and lamellæ are both invisible and a bubble formation is not formed at the hilum, as in a majority of the grains of *B. double deep rose*. The grains become more refractive after the addition of the reagent, and the first part to show this change is a rather narrow band of starch at the margin which is not so refractive as in *B. double deep rose*. Gelatinization begins at discrete points on the distal end of the grains and in a small majority of the grains proceeds exactly as in a minority of *B. double deep rose*. In a large minority it progresses very much as in a majority of the grains of *B. double deep rose,* the only difference noted being that gelatinization advances more rapidly from the proximal than from the distal margin so that the last part of the grain to be gelatinized is midway between the hilum and the distal end, instead of just distal to the hilum; and this part of the grain is never split into two pieces as in *B. double deep rose*. The gelatinized grains are as much swollen and as much distorted as in *B. double deep rose,* but have thin instead of rather thick capsules.

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 17 per cent of the entire number of grains and 65 per cent of the total starch in 5 minutes; in about 48 per cent of the grains and 93 per cent of the total starch in 15 minutes; in about 99 per cent of the grains and in more than 99 per cent of the total starch in 30 minutes. (Chart D 540.) (See pages 697 and 705.)

The hilum becomes distinct in all the grains, unattended by the formation of a bubble in any. The lamellæ are not visible. Gelatinization begins at the hilum, which swells much more rapidly in the direction of the proximal than of the distal end. Two rather indistinct fissures proceed from either side of the hilum nearly to the distal margin. The starch comprehended between these fissures is divided by fine irregular fissures and is rapidly gelatinized, leaving a small refractive granular residue at the distal end. In the meantime the portion at the proximal and distal margins and sides forms a marginal band which is broader at the distal margin than elsewhere. It is at first homogeneous-looking, but is later divided into lamellæ. This is soon dissolved at the proximal end and solution proceeds to the distal end, which is the last to be dissolved.

Comparison of the *chromic-acid* reactions between *B. socotrana* and *B. double deep rose* shows:

The hilum and lamellæ are more distinct than in *B. double deep rose*. Gelatinization begins at the hilum, which swells somewhat but no more toward the proximal than toward the distal end, and the progress of gelatinization is different from *B. double deep rose*. The starch which is comprehended between the 2 fissures from the hilum, and which is immediately distal to the hilum, is divided by a double row of slanting fissures. The grain-residue gelatinizes without any further change except that it becomes more refractive and is gradually divided into an outer homogeneous layer and an inner granular mass. The outer layer is dissolved at one corner and in some grains splits away from the inner granular mass, which may or may not be the last to be gelatinized.

The reaction with *pyrogallic acid* begins in a few grains in 1 minute. Complete gelatinization occurs in 0.5 per cent of the entire number of grains and 25 per cent of the total starch in 5 minutes; in about 32 per cent of the grains and 77 per cent of the total starch in 15 minutes; in about 40 per cent of the grains and 88 per cent of the total starch in 30 minutes; in about 52 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 56 per cent of the grains and 96 per cent of the total starch in 60 minutes. (Charts D 541 and D 542.)

The hilum becomes distinct in all the grains, unattended by the formation of a bubble in any. The lamellæ also gradually become distinct. Gelatinization begins at the hilum, which swells somewhat. Two fissures are seen to proceed from either side of the hilum practically to the distal margin, and the starch which is comprehended between them and the hilum and the distal margin is indistinctly fissured and slowly gelatinized, leaving a small refractive mass at the distal end which disappears in time, the hilum meanwhile swelling more toward the proximal than the distal end. The starch at the proximal end and sides forms at the margin a thick, refractive, homogeneous band which slowly grows thinner and more

nearly transparent until it is completely gelatinized. The gelatinized grains are moderately swollen, have thick capsules, and are somewhat distorted.

Comparison of the *pyrogallic-acid* reactions between *B. socotrana* and *B. double deep rose* shows:

The hilum and lamellæ are both somewhat more distinct than in *B. double deep rose.* The method of gelatinization differs somewhat from that described for *B. double deep rose* in the following points: Two fissures which extend from the hilum on either side are much shorter; the starch comprehended between them is divided by a double row of slanting fissures which are very distinct; when this part of the grain is gelatinized it leaves a refractive distinctly granular mass at the distal end; and the band formed from the starch at the margin is lamellated instead of being homogeneous in appearance. No further change occurs after the gelatinization of the distal material and the formation of a marginal band. (See note, page 698.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in 100 per cent of the grains and total starch in 15 seconds. (Chart D 543.)

The hilum becomes distinct in all the grains, attended by the formation of a bubble in a moderate number of grains. The lamellæ are not very distinct, but are visible. Gelatinization begins at the hilum, which enlarges more rapidly toward the proximal end than toward the distal end. Two fissures proceed from the hilum on either side and extend nearly to the distal margin, and the starch comprehended between these 2 fissures becomes irregularly granular and is rapidly gelatinized. The starch at the proximal and distal margins and sides forms a rather thin, refractive, homogeneous-looking band around the margin and this is gelatinized rather slowly.

The gelatinized grains are much swollen, have rather thin capsules, and are often considerably distorted.

Comparison of the *nitric-acid* reactions between *B. socotrana* and *B. double deep rose* shows:

The hilum becomes more distinct in all the grains than in *B. double deep rose,* but this is not attended by the formation of a bubble in any of the grains. The lamellæ also are much more distinct than in *B. double deep rose.* Gelatinization begins at the hilum which swells slightly, and it progresses very differently from that in *B. double deep rose.* The starch comprehended between the 2 fissures which extend from either side of the hilum is first divided by 2 rather indistinct rows of slanting fissures which become more and more distinct as gelatinization proceeds. This starch is slowly gelatinized, leaving small, pointed protuberances of refractive starch projecting from the sides into the center of the swelling grains. This is as far as the reaction even seems to go in the normal grains.

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 44 per cent of the entire number of grains and 80 per cent of the total starch in 1 minute; in about 98 per cent of the grains and in more than 99 per cent of the total starch in 2 minutes. (Chart D 544.)

The hilum becomes distinct, unattended by the formation of a bubble in any of the grains. The lamellæ are distinct. Gelatinization begins at the hilum, which swells somewhat, and two fissures proceed from either side of the hilum to only about half the distance between the hilum and the distal margin. The starch comprehended between these 2 fissures is indistinctly fissured near the hilum, and the distal end is also invaded by a number of longitudinal fissures which extend inward from the margin. The starch thus fissured becomes granular and is then gelatinized rapidly. The hilum meanwhile has been swelling rapidly, more toward the proximal than toward the distal end of the grain. The starch at the proximal end and sides forms at the margin a thick, indistinctly lamellated band which gradually grows thinner and more nearly transparent until it is gelatinized. As the granular distal portion of the grain is gelatinized there is an invagination of the capsule at the proximal end, which is, however, straightened out later. The gelatinized grains are much swollen, have thick capsules, and are not greatly distorted.

Comparison of the *strontium-nitrate* reactions between *B. socotrana* and *B. double deep rose* shows:

The hilum and lamellæ are more distinct than in *B. double deep rose.* Gelatinization begins at the hilum and proceeds much the same as in *B. double deep rose,* except that the 2 fissures from the hilum are more distinct and longer; the starch between them is not fissured by longitudinal fissures from the distal end, but only from the hilum; and it is also often fissured by a double row of slanting fissures which are never seen in *B. double deep rose;* and the starch at the proximal end is never observed to be invaginated during the gelatinization of the distal starch. The gelatinized grains are as much swollen, do not have such thick capsules, and are somewhat more distorted, especially at the distal end, than in *B. double deep rose.*

Begonia success (Hybrid).

(Plate 22, fig. 132; Charts D 539 to D 544.)

Histologic Properties.

In *form* the grains are always simple as in *B. socotrana,* and are usually isolated, but a few aggregates are seen which may be doublets or quadruplets arranged in a somewhat irregular mass. The grains are more regular in form than in either parent, in this respect more closely resembling *B. socotrana,* but the character of the irregularities is closer to *B. double deep rose,* except that secondary sets of lamellæ are of rare occurrence. Irregularities are due to the following: (1) A deviation of the axis and consequent bending of the grain; (2) a greater development of one part of the distal end than of the rest; (3) shallow depressions in the margin; (4) rounded protuberances from either end or side; (5) a secondary set of lamellæ whose longitudinal axis is at an angle of varying size with that of the primary set; (6) 1 or 2 pressure facets at the distal end. The conspicuous forms are elongated elliptical with flattened distal end, ovoid, and nearly round. The additional forms are round, rod-shaped, club-shaped, triangular, and irregularly quadrilateral. The broad forms, as in both parents, are somewhat flattened, and when viewed on edge have an elongated elliptical or ovoid shape. In form *B. success* shows a closer relationship to *B. socotrana* than to *B. double deep rose.*

The *hilum* is not very distinct, as in both parents. It is very rarely fissured, as in *B. double deep rose,* and the fissures have the same forms as in that starch. The

hilum is eccentric from 0.36 to 0.15, usually 0.2, of the longitudinal axis. This is 0.02 less eccentric than in *B. socotrana* and 0.06 more than in *B. double deep rose.* In the character of the hilum *B. success* shows a closer relationship to *B. double deep rose,* and in degree of eccentricity to *B. socotrana.*

The *lamellæ* are somwhat more distinct than in *B. socotrana,* but much less distinct than in *B. double deep rose.* They are usually as fine as in *B. socotrana,* but are somewhat less irregular in outline than in that grain. Otherwise in arrangement and character they are the same as in *B. socotrana.* The number counted on the larger grains varies from 30 to 40, usually 36.

In the character, arrangement, and number of the lamellæ *B. success* shows a closer relationship to *B. socotrana* than to *B. double deep rose.*

In *size* the grains vary from the smaller which are 0.6 by 0.6μ, to the larger which are 48 by 20μ, in length and breadth. The common sizes are 30 by 15μ and 28 by 19μ, which are, respectively, 2 by 1μ and 2 by 2μ less than the corresponding common sizes of *B. socotrana,* and, respectively, 6μ longer by 4μ narrower and 8μ longer than corresponding sizes in *B. double deep rose.* In size *B. success* shows a closer relationship to *B. socotrana* than to *B. double deep rose.*

Polariscopic Properties.

The *figure* is as distinct and as well defined as in *B. socotrana.* The lines cross at an acute angle which does not vary greatly in the different grains, and are usually not bent, but sometimes are bisected as in *B. socotrana.*

The *degree of polarization* varies from moderate to high (value 60), the same as in *B. socotrana* and 10 units more than in *B. double deep rose.*

With *selenite* the quadrants are as clear-cut and as regular in form as in *B. socotrana.* The colors also, as in that starch, are usually pure, except those which show a greenish tinge.

In the character of the figure, the degree of polarization, and the appearances with selenite *B. success* shows a much closer relationship to *B. socotrana* than to *B. double deep rose.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a light to moderate violet (value 30), the same as in *B. socotrana* and 15 units less than in *B. double deep rose.* With 0.125 per cent Lugol's solution the grains all color a very light violet as in *B. socotrana* and less than in *B. double deep rose.* After heating in water until all the grains are completely gelatinized and then treating with an excess of a 2 per cent Lugol's solution, the gelatinized *grains* are all colored a light to moderate, or deep indigo as in *B. socotrana,* and more than in *B. double deep rose;* the *solution* is colored a deep indigo as in *B. socotrana* and less than in *B. double deep rose.* If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the *grain-residues* all color a moderate indigo in their proximal ends as in *B. socotrana* and more than in *B. double deep rose;* the *capsules* a moderate to deep violet less than in *B. socotrana,* but more than in *B. double deep rose,* and the *solution* a very deep indigo as in both parents. Qualitatively and quantitatively the reactions with iodine show a closer relationship to *B. socotrana* than to *B. double deep rose.*

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes they are lightly to moderately colored (value 40), the same as in *B. double deep rose* and 5 units more than in *B. socotrana.*

With *safranin* the grains all color very lightly at once, and in 30 minutes they are moderately to deeply colored (value 60), the same as in *B. double deep rose* and 5 units more than in *B. socotrana.*

In the reactions with aniline stains *B. success* shows a much closer relationship to *B. double deep rose* than to *B. socotrana.*

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 63° to 64° C., and of all is 68° to 69° C., mean 68.5° C., which is 0.7° C. more than in *B. double deep rose* and 12.9° C. less than in *B. socotrana.* The temperature of gelatinization of *B. success* is much closer to that of *B. double deep rose* than to that of *B. socotrana.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 70 per cent of the grains and 86 per cent of the total starch in 5 minutes; in more than 99 per cent of the grains and total starch in 10 minutes. (Chart D 539.)

The hilum and lamellæ are not visible as in *B. socotrana.* The grains become more refractive after the addition of the reagent and the first part to show this is a rather narrow band of starch at the margin which is as refractive as in *B. double deep rose* and more refractive than in *B. socotrana.* Gelatinization begins at the distal end, and in a smaller majority than in *B. double deep rose,* immediately afterward at the proximal end. In a larger minority than in *B. double deep rose* it advances only from the distal end and the proximal end is the last part of the grain to be gelatinized. The processes, however, are the same as in *B. double deep rose* in both methods. The gelatinized grains are as much swollen, have as thick capsules, and are as much distorted as in *B. double deep rose.* In this reaction *B. success* shows qualitatively a somewhat closer relationship to *B. double deep rose* than to *B. socotrana.*

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 20 per cent of the grains and 73 per cent of the total starch in 5 minutes; in about 67 per cent of the grains and 95 per cent of the total starch in 15 minutes. (Chart D 540.) (See pages 704 and 707.)

The hilum and lamellæ are as distinct as in *B. socotrana.* Gelatinization begins at the hilum and proceeds very much as in *B. double deep rose,* except that in a moderate minority of the grains the starch between the 2 fissures is not fissured or divided into granules, but simply rapidly gelatinized, causing the marginal band at the distal end to be much broader and thicker than at the proximal end and sides. In this reaction *B. success* shows qualitatively a closer relationship to *B. double deep rose* than to *B. socotrana.*

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in 0.5 per cent of the entire number of grains and 43 per cent of the total starch in 5 minutes; in about 43 per cent of the grains and 87 per cent of the total starch in 15 minutes; in about 60 per cent of the grains and 92 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 96 per cent of the total starch in 45 minutes; in about 63 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 541.)

The hilum and lamellæ are as distinct as in *B. socotrana*. Gelatinization begins at the hilum and progresses as in *B. double deep rose*, except that the starch comprehended between the 2 fissures which proceed from either side of the hilum is usually not so distinctly fissured and that there are a few grains in which this part of the grain is divided by a double row of slanting fissures as in *B. socotrana*. The gelatinized grains are more swollen, do not have such thick capsules, and are somewhat more distorted than in *B. double deep rose*. In this reaction *B. success* shows qualitatively a closer relationship to *B. double deep rose* than to *B. socotrana*. (See note, page 698.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in 100 per cent of the entire number of grains and total starch in 15 seconds. (Chart D 543.)

The hilum becomes distinct in all the grains, attended by the formation of a bubble in more grains than in *B. double deep rose*. The lamellæ are as distinct as in *B. socotrana*. Gelatinization begins at the hilum and progresses as in *B. double deep rose*, except that the starch comprehended between the 2 fissures which proceed from the hilum is in some grains divided by a double row of slanting fissures as in *B. socotrana*, and in all the grains becomes more distinctly granular than in *B. double deep rose*. The gelatinized grains are as much swollen, have as thin capsules, and are somewhat more distorted than in *B. double deep rose*. In this reaction *B. success* shows qualitatively a somewhat closer relationship to *B. double deep rose* than to *B. socotrana*.

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 75 per cent of the entire number of grains and 88 per cent of the total starch in 1 minute; in about 98 per cent of the grains and 99 per cent of the total starch in 2 minutes. (Chart D 544.)

The hilum and the lamellæ are as distinct as in *B. socotrana*. Gelatinization begins at the hilum and progresses as in *B. double deep rose*, except that the 2 fissures which proceed from either side of the hilum are more distinct and longer and that the distal starch is rarely invaded by longitudinal fissures from the margin. A few of the grains show a double row of slanting fissures distal to the hilum, and the part bounded by the fissures is gelatinized as in *B. socotrana*. The gelatinized grains are as much swollen and have as thick capsules as in *B. double deep rose*, but are somewhat more distorted than in that starch. In this reaction *B. success* shows qualitatively a somewhat closer relationship to *B. double deep rose* than to *B. socotrana*.

12. RICHARDIA.

The basis of this genus consists of a few well-marked species that are native of South America. Some of the species and the varieties are in common cultivation and popularly known as callas, which, however, like the *Arum* callas do not belong to the true monotypic genus *Calla*.

Starches of the following parent-stocks and hybrid-stocks were studied:

40. *R. albo-maculata* Hook. (seed parent), *R. elliottiana* Knight (*Calla elliottiana* Hort.) (pollen parent), and *R. mrs. roosevelt* (hybrid).

The specimens were obtained from the growers, E. H. Krelage and Son, Haarlem, Holland.

40. Starches of Richardia albo-maculata, R. elliottiana, and R. mrs. roosevelt.

Richardia albo-maculata (Seed Parent).

(Charts D 545 to D 565.)

Histologic Properties.

In *form* the grains are simple and usually occur as separated components of aggregates with the exception of a few which appear in disintegrating aggregates, as rare complete doublets of 2 small or 1 large and 1 small component, and as permanently isolated grains. Pressure facets are present on most of the grains, and the grains are usually regular, with the exception that the sides and angles of a given polygonal grain may occasionally show a variation, and that depressions, probably due to pressure, may occur at indefinite points upon the surface of rounded and ellipsoidal grains. The conspicuous forms of the separated component grains are polygonal, low dome-shaped with squared or pointed distal end, high dome-shaped with a plane or concave distal end, and rounded with concave distal end. The conspicuous forms of the permanently isolated grains are round, nearly round, and ellipsoidal. The grains are not flattened, excepting at the pressure facets.

The *hilum* is usually indistinct and seldom unfissured. It is occasionally observed as a round, non-refractive spot. A small, rounded cavity is rarely present. The hilum is centric in the majority of grains, but may have a range of eccentricity from 0.45 to 0.35, rarely 0.25, of the longitudinal axis.

The *lamellæ* are not usually demonstrable, but can occasionally be observed as moderately fine rings which are circular near the hilum and elsewhere have the form of the outline of the grain. The number throughout the entire grain can rarely be counted, but there may be 8 on some of the larger, dome-shaped doublets.

The *size* of the grains varies from the smaller which are 3 by 2μ, to the larger permanently isolated grains which are 16 by 16μ, and the larger separated components which are 16 by 24μ, in length and breadth. The common size of the separated components is about 8 by 7μ, of the originally isolated grains 12 by 12μ, in length and breadth.

Polariscopic Properties.

The *figure* is usually centric to slightly eccentric, rarely quite eccentric, with more of the centric. The figure is usually distinct, although occasionally the lines are not clear throughout entire figure. The lines are

usually fine and intersect either at right angles or obliquely. They are generally straight and often with broadening at margin, but they may be bent and bisected. Double and multiple figures are occasionally observed.

The *degree of polarization* is moderate to high (value 70). It varies in the different grains from moderate to high with more of the latter. A variation is also often found in the same aspect of a given grain, or one quadrant may be moderate or even low, while the remainder are high.

With *selenite* the quadrants in most of the grains are moderately clean cut—quite clean cut in the larger permanently isolated grains. In the majority of grains they are slightly irregular in shape and somewhat unequal in size, but often regular and equal in the permanently isolated grains. The blue is generally pure, but the yellow is frequently impure.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains immediately color a moderate blue-violet (value 45), which deepens rapidly, becoming bluer in tint. With 0.125 per cent Lugol's solution they color a light blue-violet, which deepens rapidly, becoming bluer in tint. After heating in water until the grains are gelatinized and then adding a 2 per cent Lugol's solution, some of the *grains* color a moderate and most of them a moderately deep indigo-blue; and the *solution* a moderately deep indigo-blue. If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* color a light to moderate blue, more of the latter, most of them with a reddish tint; the *capsules* become a deep old-rose to a deep reddish-heliotrope, with many of the latter; and the *solution* a deep indigo-blue.

Aniline Reactions.

With *gentian violet* the grains color very faintly at once, and in half an hour they are lightly stained (value 30).

With *safranin* the grains color very lightly at once and in half an hour they are lightly stained (value 33). The grains color a little deeper with safranin than with gentian violet.

Temperature Reactions.

The majority of the grains are gelatinized at 75° to 76° C., and all at 77° to 78.5° C., mean 77.7° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 88 per cent of the entire number of grains and 95 per cent of the total starch in 3 minutes; in about 98 per cent of the grains and more than 99 per cent of the total starch in 5 minutes. (Chart D 545.)

The hilum becomes very prominent and a bubble is often formed there. Many grains, practically all, have pressure facets at the sides and distal ends; two lines or canals are seen to extend from the hilum to the corners of the pressure facets. No lamellæ are visible. A narrow refractive band is formed rather slowly about the margin of the more resistant grains. Gelatinization begins in the smaller grains, and in the larger less resistant grains, in all parts of the interior of the grain at once. In the more resistant grains, it begins either at the distal corners at the end of the two canals already mentioned in connection with the hilum, or, occasionally, at the proximal end. According to the first method, the entire grain becomes gradually more transparent and gelatinous in appearance and at the same time swells equally in all directions. According to the second, the marginal starch at the facet corners gelatinizes, then the two canals and the hilum become broader, thus causing the grain to lengthen transversely, and dividing the starch of the grain into two parts; of these parts, the proximal or larger is usually gelatinized before the distal. According to the last method the proximal margin becomes gelatinized first, and gelatinization proceeds from this point evenly and equally over the whole grain. If a bubble is present at the hilum, it shrinks and disappears when the hilum is reached in the progress of gelatinization. The gelatinized grains are moderately large and somewhat distorted, but retain much resemblance to the form of the untreated grain.

The reaction with *chromic acid* begins in half a minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 45 per cent of the total starch in 15 minutes; in about 42 per cent of the grains and 96 per cent of the total starch in 30 minutes; in about 80 per cent of the grains and 98 per cent of the total starch in 45 minutes; complete gelatinization with the exception of a portion of the margin of rare grains and over 99 per cent of both the grains and total starch in 60 minutes. (Chart D 546.)

The hilum does not become distinct until gelatinization has begun, and then two canals or fissures may sometimes be seen extending from the hilum to the distal pressure-facet corners, and in other grains there may be seen irregular fissures extending into the body of the grain. The lamellæ are usually not visible, but in some grains evidences of a lamellar structure may be made out as gelatinization progresses. Gelatinization begins at the hilum and is accompanied or preceded by the appearance of a number of striæ radiating from the hilum to the margin, which divide the starch of the grain into long, fine spicules. As the hilum enlarges, deep irregular cracks extend from it into the body of the grain. The ungelatinized starch collects at the margin in a striated band which becomes more and more nearly transparent, and small cracks invade the grain from the margin at which points gelatinization proceeds more rapidly. In some grains these cracks undoubtedly mean a dissolution of the capsule and a final dissolution of the grain, but in others the capsule appears to remain unbroken; and these remain as thin-capsuled, very transparent completely gelatinized grains which do not retain much of the form of the untreated grain.

The reaction with chromic acid advances uniformly in a number of grains until a few of the outermost lamellæ are reached; these layers for a while are quite resistant, which results in making the percentage of grains completely gelatinized quite low while that of the total starch is relatively high. Between the observations of 15 and 30 minutes these resistant outermost layers become gelatinized in many grains and hence at 30 minutes a relatively large percentage of the entire number of grains is completely gelatinized; and as the reaction advances

the differences between the percentages of grains gelatinized and of the total starch become lessened.

The reaction with *pyrogallic acid* begins in a few grains immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 9 per cent of the total starch in 30 minutes; in about 5 per cent of the grains and 10 per cent of the total starch in 45 minutes; in about 6 per cent of the grains and 11 per cent of the total starch in 60 minutes. (Chart D 547.)

The reaction with *nitric acid* begins immediately in a few grains. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 16 per cent of the grains and 22 per cent of the total starch in 15 minutes; in about 18 per cent of the grains and 28 per cent of the total starch in 30 minutes; in about 30 per cent of the grains and 40 per cent of the total starch in 45 minutes; in about 36 per cent of the grains and 48 per cent of the total starch in 60 minutes. (Chart D 548.)

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 87 per cent of the entire number of grains and 97 per cent of the total starch in 5 minutes; in about 98 per cent of the grains and in more than 99 per cent of the total starch in 10 minutes. (Chart D 549.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 9 per cent of the entire number of grains and 18 per cent of the total starch in 5 minutes; in about 25 per cent of the grains and 35 per cent of the total starch in 15 minutes; in about 43 per cent of the grains and 62 per cent of the total starch in 30 minutes; in about 50 per cent of the grains and 75 per cent of the total starch in 45 minutes; in about 56 per cent of the grains and 82 per cent of the total starch in 60 minutes. (Chart D 550.)

The hilum becomes moderately distinct, and the lamellæ are not visible. Gelatinization begins at the hilum, and as the hilum grows larger striæ radiate in all directions from it to the margin, and the starch thus separated becomes granular as gelatinization proceeds; in the meantime several deep cracks appear in the margin of the grain, the capsule is evidently dissolved at these points, and granules separate off from the ungelatinized starch, float off, and are dissolved. The few grains which are completely gelatinized before dissolution are large and distorted and do not retain much of the form of the untreated grain.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 8 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 10 per cent of the total starch in 30 minutes; in about 5 per cent of the grains and 13 per cent of the total starch in 45 minutes; in about 13 per cent of the grains and 21 per cent of the total starch in 60 minutes. (Chart D 551.)

The hilum becomes moderately distinct, and in some grains 2 canals or fissures are seen to extend from the hilum to the distal corners of the pressure facets, and these enlarge as the hilum enlarges. The lamellæ are not visible until gelatinization is far advanced. Gelatinization begins at the hilum, which begins to enlarge, and at the same time the substance of the grain is divided into long spicules by fine striæ radiating from the hilum to the margin. As the hilum and the grain continue to enlarge the more resistant starch is pushed to the margin, and there forms a lamellated band which is divided into small granules by the striæ mentioned, which striæ have been spread apart during the swelling of the grain. The starch in the interior of the grain, in the meantime, has become granular, and remains so until the marginal starch is completely gelatinized. The gelatinized grains are moderately large and somewhat distorted, but show some of the form of the untreated grain.

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 85 per cent of the entire number of grains, and 92 per cent of the total starch in 3 minutes; in about 96 per cent of the grains and 99 per cent of the total starch in 5 minutes; in more than 99 per cent of both the grains and total starch in 10 minutes. (Chart D 552.)

The hilum becomes moderately distinct, and a bubble is often formed there before gelatinization begins. Extending from the hilum to the distal pressure-facet corners in many grains are 2 lines or canals. The lamellæ are not seen. Gelatinization begins in the less resistant grains at the hilum and in the more resistant at the distal corners of the pressure facets; in the first named, the grain becomes nearly transparent and the hilum swells, and the bubble if present swells, shrinks, and then disappears, at first pushing the ungelatinized starch to the margin, where it is soon gelatinized. During this process the intracapsular and capsular parts swell somewhat unevenly and become very large, with many long folds in the capsule. In the second-named grains, the marginal starch at the pressure-facet angles gelatinizes and the grain broadens transversely, as the hilum and the lines connecting it with the pressure-facet angles swell somewhat; and the bubble if present, swells, shrinks, and disappears. The ungelatinized portion of the starch is by this method divided into two portions, proximal and a distal, of which the distal starch gelatinizes first. The gelatinized grains are moderately large and somewhat distorted, some retain somewhat of the form of the untreated grain and others do not.

Richardia elliottiana (Pollen Parent).

(Charts D 545 to D 552.)

Histologic Properties.

In *form* the grains are simple and usually occur as separated components of aggregates with the exception of a few which appear in disintegrating aggregates, and as permanently isolated grains. No complete doublets were observed, and the permanently isolated grains are fewer in number than in *R. albo-maculata.* Pressure facets are present on most grains, as in *R. albo-maculata.* The grains are usually regular in form, and the same forms of irregularities may occur, as in *R. albo-maculata.* Rounded and ellipsoidal grains with identations at indefinite points are more numerous than in the latter species. The conspicuous forms of the separated components are polygonal, high dome-shaped with a plane or concave distal end, low dome-shaped with a plane or pointed dis-

tal end, and ellipsoidal with one or more concavities at the distal end. The conspicuous forms of the permanently isolated grains are ellipsoidal, nearly round, and round. The grains are not flattened excepting at the pressure facets, as in *R. albo-maculata.* The forms of the grains of the two parent species are closely alike, the main differences being in the quantitative distribution of the different kinds of grains.

The *hilum* is frequently indistinct, but is demonstrable in more grains than in *R. albo-maculata,* and is a small, round, non-refractive spot, as in *R. albo-maculata.* A small, rounded cavity is present at the hilum in more grains than in *R. albo-maculata,* the hilum is more often fissured than in *R. albo-maculata,* and the fissures are short, and transverse, or cruciate, or Y-shaped. The position of the hilum is centric in the majority of grains, but it may have a range of eccentricity from 0.45 to 0.35, rarely 0.25, of the longitudinal axis; there are somewhat fewer grains with a centric hilum, and more with a slight eccentricity than in *R. albo-maculata.* The main differences between the grains of the two species are in the more frequent fissuration, the more frequent appearance of the hilum, and the greater tendency to eccentricity of the hilum in *R. elliottiana.*

The *lamellæ* are frequently not demonstrable, although they can be made out in more grains than in *R. albo-maculata.* When observed they are found to be of the same structure and arrangement as in *R. albo-maculata.* The number can be determined more often than in *R. albo-maculata;* that of the larger dome-shaped component grains is usually 8, and on the larger permanently isolated grains 12. The lamellæ, while of the same character and arrangement, are more numerous in *R. elliottiana.*

The *size* varies from the smaller grains which are 3 by 2μ, to the larger permanently isolated grains which are 16 by 14μ, and the larger separated components which are 22 by 22μ, in length and breadth. The common size of the separated component grain is about 9 by 7μ, and of the permanently isolated grains 12 by 10μ in length and breadth. The size is slightly larger, on the whole, than in *R. albo-maculata.*

Polariscopic Properties.

The *figure* is usually centric to slightly eccentric, rarely quite eccentric, and there are fewer of the centric and more of the slightly eccentric figures than in *R. albo-maculata.* The figure is distinct in the majority of grains, but the lines are less often clear throughout the entire figure than in *R. albo-maculata.* The lines are fine in the majority of the grains, and intersect either at right angles or obliquely, but they are quite broad in more grains than in *R. albo-maculata.* They are generally straight, often with broadening at the margin, but may be bent and bisected as in *R. albo-maculata.* Double and multiple figures are occasionally observed as in *R. albo-maculata.*

The *degree of polarization* is moderate to high (value 65), somewhat lower than in *R. albo-maculata.* It varies in the different grains from moderate to high with more of the former than in *R. albo-maculata.* The same variation is found in a given grain as in *R. albo-maculata,* but the grains with one or more quadrants in which the degree of polarization is low are more common.

With *selenite* the quadrants in the majority of grains are moderately clean-cut, sometimes quite clean-cut in the larger permanently isolated grains; but there are fewer grains in which the quadrants are clean-cut than in *R. albo-maculata.* The quadrants are generally unequal in size and slightly to quite irregular in shape. They are unequal and irregular in considerably more grains than in *R. albo-maculata.* The blue is pure in the majority of grains, while the yellow is not usually pure. The colors are less often pure than in *R. albo-maculata.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains color a moderate violet (value 40), which is redder in tint at first, and after deepening very rapidly to about the same depth it is still not so blue as in *R. albo-maculata.* With 0.125 per cent Lugol's solution the grains color a light violet of almost the same depth, but more reddish, than in *R. albo-maculata.* After heating in water until the grains are gelatinized and then adding 2 per cent Lugol's solution they color a moderate to moderately deep indigo-blue, somewhat more grains of the former and hence lighter than in *R. albo-maculata;* the *solution* colors a moderately deep indigo-blue as in *R. albo-maculata.* If the preparation is boiled for 2 minutes, and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* become a light to moderate blue with majority of the former, and in most of them with reddish tint, the color being lighter than in *R. albo-maculata;* most of the *capsules* color an old-rose, and a few a wine-red color, and they are lighter and somewhat redder than in *R. albo-maculata.* The *solution* is a deep indigo-blue as in *R. albo-maculata.*

Aniline Reactions.

With *gentian violet* the grains color faintly at once, and in half an hour they are lightly stained (value 33), but slightly deeper than in *R. albo-maculata.*

With *safranin* the grains color very lightly at once, and in half an hour they are lightly colored (value 35), slightly deeper than in *R. albo-maculata.* The grains color a little deeper with safranin than with gentian violet, as in *R. albo-maculata.*

Temperature Reactions.

The majority of the grains are gelatinized at 74° to 75° C., and all at 76° to 77° C., mean 76.5° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 83 per cent of the entire number of grains and 92 per cent of the total starch in 3 minutes; in about 90 per cent of the grains and 97 per cent of the total starch in 5 minutes. (Chart D 545.)

The hilum becomes moderately distinct, and a bubble is occasionally formed there. In some grains, also lines or canals leading from the hilum to the distal corners of the pressure facets may be seen. No lamellæ are visible. A narrow refractive band is formed slowly about the margin of the more resistant grains. Gelatinization begins in the small grains and in many of the larger grains in all parts at once; in a few of the more resistant grains, at the corners of the pressure facets; and in most of the rest, at one distal corner or at the proximal end, in

this latter differing from the majority of grains in *R. albo-maculata.* The progress of gelatinization from the beginning of these various methods is the same as described under *R. albo-maculata.* The gelatinized grains are moderately large and somewhat distorted, but retain much of their original form as in *R. albo-maculata.*

The reaction with *chromic acid* begins in half a minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 68 per cent of the total starch in 15 minutes; in about 60 per cent of the grains and 97 per cent of the total starch in 30 minutes; in about 88 per cent of the grains and 99 per cent of the total starch in 45 minutes; complete gelatinization occurs with the exception of a portion of the margin of rare grains and over 99 per cent of both the grains and total starch in 60 minutes. (Chart D 546.)

The hilum becomes distinct sooner than in *R. albo-maculata,* but evidence of a lamellar structure is less often seen than in that species. Gelatinization begins at the hilum and the process is essentially the same as in *R. albo-maculata,* except that the striæ from the hilum to the margin are not so marked, nor are cracks invading the margin from without so often noted. Most of the gelatinized grains persist, and few are seen to be completely dissolved. They are large and thin-walled as in *R. albo-maculata.*

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 15 minutes; in about 3 per cent of the grains and 5 per cent of the total starch in 30 minutes; in about 4 per cent of the grains and 7 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 9 per cent of the total starch in 60 minutes. (Chart D 547.)

The reaction with *nitric acid* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 4 per cent of the total starch in 5 minutes; in about 10 per cent of the grains and 16 per cent of the total starch in 15 minutes; in about 10 per cent of the grains and 20 per cent of the total starch in 30 minutes; in about 12 per cent of the grains and 30 per cent of the total starch in 45 minutes; in about 20 per cent of the grains and 36 per cent of the total starch in 60 minutes. (Chart D 548.)

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 90 per cent of the entire number of grains and 98 per cent of the total starch in 5 minutes; in more than 99 per cent of the grains and total starch in 10 minutes. (Chart D 549.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 8 per cent of the entire number of grains and 16 per cent of the total starch in 5 minutes; in about 20 per cent of the grains and 33 per cent of the total starch in 15 minutes; in about 41 per cent of the grains and 55 per cent of the total starch in 30 minutes; in about 55 per cent of the grains and 70 per cent of the total starch in 45 minutes; in about 66 per cent of the grains and 80 per cent of the total starch in 60 minutes. (Chart D 550.)

The hilum becomes moderately distinct, but less so than in *R. albo-maculata.* The lamellæ are not visible. Gelatinization begins at the hilum and the process is very similar to that in *R. albo-maculata,* except that the striæ and granules formed after the beginning of gelatinization are not so large nor so distinct, and the margin is less invaded by cracks, and hence fewer of the grains are dissolved than in that starch. The completely gelatinized grains are the same in appearance as *R. albo-maculata.* They are large, distorted, and do not retain much of the form of the untreated grain.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 8 per cent of the total starch in 5 minutes; in about 4 per cent of the entire number of grains and 13 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 14 per cent of the total starch in 30 minutes; in about 6 per cent of the grains and 17 per cent of the total starch in 45 minutes; in about 14 per cent of the grains and 23 per cent of the total starch in 60 minutes. (Chart D 551.)

The hilum becomes as distinct as in *R. albo-maculata,* but in only some of the grains are 2 canals seen to extend from the hilum to the distal corners of the pressure facets. The lamellæ are not visible at any stage of the reaction. Gelatinization begins at the hilum and in some grains also at the distal corners of the pressure facets. The progress of gelatinization is very similar to that in *R. albo-maculata,* except that at no time in the reaction is there evidence of lamellar structure, and the striæ radiating from the hilum to the margin are not so distinct, but the granules in the gelatinized interior are larger and more distinct. The gelatinized grains are moderately large and somewhat distorted, but retain more of the form of the untreated grain than those of *R. albo-maculata.*

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 80 per cent of the entire number of grains and 91 per cent of the total starch in 3 minutes; in about 96 per cent of the grains and 99 per cent of the total starch in 5 minutes; in more than 99 per cent of both the grains and total starch in 10 minutes. (Chart D 552.)

The hilum is more distinct than in *R. albo-maculata,* and a bubble is often formed there. The lamellæ are not visible. Gelatinization begins at the hilum in more grains than in *R. albo-maculata,* and in the rest at the distal corners of the pressure facets as in *R. albo-maculata.* The methods of gelatinization do not differ from those described under *R. albo-maculata.* The gelatinized grains are large and considerably distorted, more so than in *R. albo-maculata.*

Richardia Mrs. Roosevelt (Hybrid).

(Charts D 545 to D 552.)

Histologic Properties.

In *form* the grains are simple and usually occur as separated components of aggregates, with the exception of a few which appear in disintegrating aggregates and in quite rare permanently isolated grains. No complete doublets, as noted for *R. albo-maculata* but not in *R. elliottiana,* were observed. The permanently isolated grains are fewer in number than in either parent. Pres-

sure facets are found on most of the grains; they are even more numerous than in either parent. The grains are usually regular, but the same irregularities may occur as noted for both parents; the depressions at indefinite points on the rounded and ellipsoidal grains are more frequent than in either parent. The conspicuous forms of the separated grains are the same as in both parents, but the polygonal ones are even more numerous than in either parent. The conspicuous forms of the rare permanently isolated grains are the same as in both parents. The grains are not flattened, excepting at the pressure facets as noted for both parents. In form these grains are slightly nearer *R. elliottiana*, though there are only minor differences to be noted between the starches.

The *hilum* is not usually demonstrable, even less frequently than in either parent. Occasionally it can be observed as a small, round, non-refractive spot. A rounded cavity is somewhat more frequently present at the hilum than in either parent. Occasionally, a small, transverse fissure is found at the hilum, more frequently than in *R. albo-maculata*, but less often fissured than in this starch. The position of the hilum is centric in the majority of the grains, but it may have a range of eccentricity from 0.45 to 0.35, rarely 0.25, of the longitudinal axis. There are fewer grains with a centric, but more with a slightly eccentric hilum, than in *R. albo-maculata;* but less of the slightly eccentric and more of the centric than in *R. elliottiana.* In the character of the hilum these grains are slightly closer to *R. albo-maculata* than to *R. elliottiana*, but there are few differences to be noted between the starches.

The *lamellæ* are rarely demonstrable, even less often than in both parents. When made out they have the same structure and arrangement as in both parents. No grains were observed in which the lamellæ could be counted over the entire grain, rarely 6 were counted from the hilum to a narrow marginal border in which they could be determined. In the character of the lamellæ *R. mrs. roosevelt* is slightly closer to *R. albo-maculata* than to *R. elliottiana.* There is, however, little difference to be noted between the starches.

The *size* of the grains varies from the smaller which are 3 by 2μ, to the larger permanently isolated grains which are 15 by 13μ, and the larger separated components which are 15 by 14μ, in length and breadth. The common size of the permanently isolated grains is about 10 by 10μ, and of the separated component about 8 by 7μ, in length and breadth. In size *R. mrs. roosevelt* is very slightly closer to *R. albo-maculata* than to *R. elliottiana*, but the permanently isolated grains are smaller than in either parent.

Polariscopic Properties.

The *figure* is usually centric to slightly eccentric, rarely quite eccentric as in both parents. While the figure is centric in the majority of the grains, it is slightly eccentric in more grains than in *R. albo-maculata*, but in less than in *R. elliottiana.* The figure is distinct in many grains, but it is more often indistinct than in either parent. The lines are frequently fine and intersect either at right angles or obliquely as in both parents. The lines are, however, sometimes broad, more often than in *R. albo-maculata*, and the same as in *R. elliottiana.* They are generally straight, often with broadening at the margin, but may be bent and bisected, as in both parents. Double and multiple figures are found, about as numerous as in both parents.

The *degree of polarization* is moderate to high (value 67), slightly lower than in *R. albo-maculata*, and a trifle higher than in *R. elliottiana.* The same variation in the different grains and in the same aspect of a given grain is present as in both parents, but the proportion of grains of moderate polarization, as well as those in which one or more quadrants are low, is greater than in *R. albo-maculata*, while the proportion of grains with high polarization is slightly greater and variation in the same aspect of a given grain is the same as in *R. elliottiana.*

With *selenite* the quadrants are generally moderately clean-cut, quite clean-cut in the few larger permanently isolated grains. They are not quite so clean-cut as in *R. albo-maculata*, but more so than in *R. elliottiana.* They are usually somewhat unequal in size and slightly irregular in shape, and somewhat more grains are unequal and irregular than in *R. albo-maculata*, but less than in *R. elliottiana.* The blue is generally pure, while the yellow is often impure; the colors are scarcely as pure as in *R. albo-maculata*, but more pure than in *R. elliottiana.*

In figure, the degree of polarization, and the reaction with selenite, the grains are somewhat closer to *R. elliottiana* than to *R. albo-maculata.* There are, however, no marked differences between the starches.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains color a moderate blue-violet, about the same tint as *R. albo-maculata* (value 45), more blue than in *R. elliottiana.* The color deepens very rapidly, becoming more bluish with considerable variation in depth of the different grains. The grains deepen even more rapidly than in *R. albo-maculata* and about the same as in *R. elliottiana*, but there is more variation in depth, making the mean coloration lighter than in either parent. With 0.125 per cent Lugol's solution the grains color a light blue-violet, a trifle deeper but of about the same tint as in *R. albo-maculata*, more bluish and a trifle deeper than in *R. elliottiana;* the color deepens rapidly to about the same depth as in *R. albo-maculata*, but a little deeper than in *R. elliottiana.* After heating in water until the grains are gelatinized and then adding 2 per cent Lugol's solution, the gelatinized *grains* color a moderate to moderately deep indigo-blue with more of the former than in either parent, and hence the mean is lighter. If the preparation is boiled for 2 minutes and then treated with 2 per cent Lugol's solution, the *grain-residues* become a light to moderate blue with a reddish tint, not so many of the deeper tint as in *R. albo-maculata*, but more than in *R. elliottiana.* The *capsules* color a light old-rose to deep reddish-heliotrope, not as many of the deep as in *R. albo-maculata*, but more of the deeply colored, though of less reddish tint, than in *R. elliottiana.* Qualitatively and quantitatively the iodine reactions show a closer resemblance to *R. albo-maculata* than to *R. elliottiana.*

Aniline Reactions.

With *gentian violet* the grains color faintly at once, and in half an hour they are lightly stained (value 35), a little deeper than in either parent.

With *safranin* the grains stain very lightly at once, and in half an hour they are lightly to moderately colored (value 38), slightly deeper than in both parents. The color with safranin is a little deeper than with gentian violet, as noted for both parents.

In the aniline reactions the resemblances are closer to *R. elliottiana* than to *R. albo-maculala.*

Temperature Reactions.

The majority of the grains are gelatinized at 74° to 76° C., and of all at 76° to 78° C., mean 77° C. The temperature of gelatinization is slightly nearer that of *R. elliottiana* (mean 76.5°) than of *R. albo-maculata* (mean 77.7°), practically exactly mid-intermediate.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 89 per cent of the grains and 99 per cent of the total starch in 3 minutes; in about 98 per cent of the grains and more than 99 per cent of the total starch in 5 minutes. (Chart D 545.)

The hilum becomes more distinct than in *R. elliottiana,* but the reaction is more like that in this starch than in *R. albo-maculala,* and the formation of bubbles is of rarer occurrence than in *R. elliottiana.* No lamellæ are visible. A narrow, refractive band forms slowly about the margin of the more resistant grains. Gelatinization begins in the smaller grains and in the less resistant larger grains in all parts of the interior at once—in the more resistant grains it usually begins at the 2 distal corners at which end the 2 canals from the hilum as in *R. albo-maculata,* and in the others either at the proximal end or at one distal corner. The progress of gelatinization following these various methods of starting has been described under *R. albo-maculala.* The gelatinized grains are moderately large and somewhat distorted as in both parents. In this reaction *R. mrs. roosevelt* shows qualitatively, on the whole, a closer resemblance to *R. albo-maculata* than to *R. elliottiana.*

The reaction with *chromic acid* begins in half a minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 67 per cent of the total starch in 15 minutes; in about 66 per cent of the grains and 97 per cent of the total starch in 30 minutes; in about 95 per cent of the grains and over 99 per cent of the total starch in 45 minutes; complete gelatinization occurs in 100 per cent of both the entire number of grains and total starch in 60 minutes. (Chart D 546.)

The hilum becomes distinct very slowly as in *R. albo-maculata,* but irregular fissuration at the hilum is less noticeable than in that starch. Lamellar structure may be noted in some grains as gelatinization proceeds. Gelatinization begins at the hilum and is nearly the same as noted under *R. albo-maculata,* except that the margin is more often invaded by cracks than in *R. albo-maculata* and the gelatinized grains are nearly always dissolved. In this latter respect it varies widely from *R. elliottiana* and is closer to *R. albo-maculata.* In this reaction *R. mrs. roosevelt* qualitatively shows a closer relationship to *R. albo-maculata* than to *R. elliottiana.*

The reaction with *pyrogallic acid* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 3 per cent of the total starch in 5 minutes; in about 2 per cent of the grains (the same as in 5 minutes) and 4 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 6 per cent of the total starch in 30 minutes; in about 6 per cent of the grains and 7 per cent of the total starch in 45 minutes; in about 6 per cent of the grains (the same as in 45 minutes) and 8 per cent of the total starch in 60 minutes. (Chart D 547.)

The reaction with *nitric acid* begins in a few grains immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 12 per cent of the grains and 16 per cent of the total starch in 15 minutes; in about 17 per cent of the grains and 22 per cent of the total starch in 30 minutes; in about 21 per cent of the grains and 36 per cent of the total starch in 45 minutes; in about 27 per cent of the grains and 41 per cent of the total starch in 60 minutes. (Chart D 548.)

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 86 per cent of the entire number of grains and 97 per cent of the total starch in 5 minutes; in more than 99 per cent of the grains and total starch in 10 minutes. (Chart D 549.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 8 per cent of the entire number of grains and 16 per cent of the total starch in 5 minutes; in about 14 per cent of the grains and 29 per cent of the total starch in 15 minutes; in about 32 per cent of the grains and 50 per cent of the total starch in 30 minutes; in about 44 per cent of the grains and 61 per cent of the total starch in 45 minutes; in about 52 per cent of the grains and 77 per cent of the total starch in 60 minutes. (Chart D 550.)

The hilum is not so distinct as in *R. albo-maculala,* and is the same as in *R. elliottiana.* Gelatinization begins at the hilum and the process is the same as that described under *R. albo-maculata,* except that the granules and striæ are finer as in *R. elliottiana.* There are more grains dissolved than in *R. elliottiana,* and about as many as in *R. albo-maculata.* The gelatinized grains are like those of the parents. In this reaction *R. mrs. roosevelt* shows qualitatively a closer resemblance to *R. albo-maculata* than to *R. elliottiana,* but there are few marked differences in the behavior of the three starches.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 9 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 14 per cent of the total starch in 15 minutes; in about 8 per cent of the grains and 15 per cent of the total starch in 30 minutes; in about 16 per cent of the grains and 25 per cent of the total starch in 45 minutes; in about 18 per cent of the grains and 38 per cent of the total starch in 60 minutes. (Chart D 551.)

The hilum is moderately distinct as in the parents, and in only a few grains is there any evidence of the lamellar structure as noted in nearly all the grains of *R. albo-maculata,* and in more of those of *R. elliottiana.* Gelatinization begins at the hilum as in *R. albo-maculata* and the process is the same as in that starch. *R. elliottiana* varies somewhat, but only slightly from the other

two. In this reaction *R. mrs. roosevelt* shows qualitatively a closer resemblance to *R. albo-maculata* than to *R. elliottiana*, but there are very little differences in the reaction of the three starches.

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 89 per cent of the entire number of grains and 94 per cent of the total starch in 3 minutes; in about 99 per cent of the grains and more than 99 per cent of the total starch in 5 minutes; complete gelatinization occurs in 100 per cent in 10 minutes. (Chart D 552.)

The hilum becomes distinct as in *R. albo-maculata*. No lamellæ are visible. Gelatinization begins more frequently at the distal corners of the pressure facets than in either parent, and rarely, at the hilum, and in this is nearer to *R. albo-maculata* than to *R. elliottiana*. The progress of gelatinization in each case is the same as that described under *R. albo-maculata*. The gelatinized grains are large and considerably distorted, the same as *R. albo-maculata*. In this reaction *R. mrs. roosevelt* shows qualitatively a somewhat closer relationship to *R. albo-maculata* than to *R. elliottiana*, though but few differences are to be seen in the reactions of the three starches.

13. MUSA.

The genus *Musa* includes about 20 species of tropical plants that are widely distributed, especially in the tropical regions of the Old World. Some of the species and varieties are extensively cultivated. Starches of the following parent-stocks and hybrid-stocks were studied:

41. *M. arnoldiana* Hort. (seed parent), *M. gilletii* Hort. (pollen parent), and *M. hybrida* (hybrid).

The specimens were obtained from the growers, Haage and Schmidt, Erfurt, Germany.

41. Starches of Musa arnoldiana, M. gilletii, and M. hybrida.

Musa arnoldiana (Seed Parent).

(Plate 23, fig. 133; Charts D 553 to D 573.)

Histologic Properties.

In *form* the grains are usually simple and isolated, only a very few compound grains and no aggregates are seen. The compound grains belong to but one type: 2 small simple grains at the proximal end of a large grain, all being surrounded by 20 to 30 common secondary lamellæ. An occasional isolated grain is seen which has a pressure facet on the distal end, indicating previous existence as part of an aggregate. The grains are usually moderately regular in form, and any irregularities are due to the following causes: (1) A greater development of one part of the distal end than the rest; (2) a deviation of the longitudinal axis at the center or at the distal end, and a consequent bending of the grain; (3) notches and other shallow or deep depressions in the margin, usually at the distal end; (4) a secondary set of lamellæ whose longitudinal axis is at an angle, usually about 90°, with that of the primary set; (5) small nipple-like or larger pointed projections, usually from the proximal end. The conspicuous forms are triangular with curved base and rounded angles, short and elongated elliptical, and ovoid with flattened distal end. The additional forms are oyster-shell-shaped, pyriform, lenticular, irregularly polygonal, and quadrilateral forms with rounded angles. When viewed on edge all the larger grains are very much flattened and have an irregular rod-shape. Many of the grains of this specimen are deeply fissured, the fissures having no relation to the hilum; and many also show erosions of the margin at the distal end.

The *hilum* is a distinct, round or lenticular spot which is rarely fissured. The fissures when they are present have the following forms: (1) An irregularly stellate arrangement of many short fissures; (2) a small, single, straight, transverse or oblique line. The hilum is eccentric from 0.35 to 0.13, usually 0.23, of the longitudinal axis.

The *lamellæ* are distinct, rather fine rings which near the hilum and in the proximal half of the grains are regular, continuous, and round or oval in shape. In the rest of the grain they have the form of the outline of the grain, often more or less modified; they are not so fine, and often show a wavy outline and become discontinuous as they near the distal end. There is usually 1 and sometimes 2 to 5 or 6 very refractive, coarse lamellæ which either form a band across the distal two-thirds of the grain and separate the fine proximal from the less fine distal lamellæ, or divide the fine lamellæ into bands of varying breadth. The number counted on the larger grains varies from 20 to 42, commonly 30.

In *size* the grains vary from the smaller which are 6 by 6μ, to the larger broad forms which are 44 by 56μ, and the larger elongated forms which are 48 by 20μ, in length and breadth. The common sizes are 30 by 32μ and 30 by 28μ.

Polariscopic Properties.

The *figure* is distinct and usually not well defined, especially near the margin. The lines cross at acute angles of widely varying size. They are often bent and sometimes bisected, and at times each is divided into 4 or 5 lines near the margin.

The *degree of polarization* varies from low to high (value 40). In most of the grains it is moderate, in a few it is low, and in fewer it is high. There is considerable variation in a given aspect of an individual grain.

With *selenite* the quadrants are usually not clear-cut. They are very unequal in size and often irregular in shape. The colors are usually not pure, and the yellow is less pure than the blue, but in a few grains both are pure.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate blue-violet (value 55). The color deepens very rapidly until it is very deep and more bluish. With 0.125 per cent Lugol's solution the grains all color lightly to moderately and the color deepens rapidly, more rapidly in some grains than in others. After heating in water until the grains are all gelatinized, and then treating with 2 per cent Lugol's solution, the *grains* all color a light or a light to moderate indigo, and the *solution* a very deep indigo. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the *grain-residues* usually do

not color at all, but some color a very light to a light indigo; the *capsules* all color a red or a reddish violet, and the *solution* a very deep indigo-blue.

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes they are lightly to deeply colored (value 50). A few of the grains are lightly colored, most of them are moderately colored, and a few are deeply colored. There is no variation in depth of color in different parts of an individual grain.

With *safranin* the grains all color very lightly at once, and in 30 minutes they are moderately to deeply colored (value 60). Most of the grains are moderately colored, and some are moderately to deeply colored. There is no variation in the depth of color in different parts of an individual grain.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 60° to 61.5° C., and of all 64.2° to 65.8° C., mean 65° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in rare grains in 30 seconds. Complete gelatinization occurs in about 40 per cent of the entire number of grains and 55 per cent of the total starch in 5 minutes; in about 80 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 97 per cent of the grains and in more than 99 per cent of the total starch in 30 minutes. (Chart D 553.)

The hilum becomes distinct, unattended by the formation of a bubble, except in a few grains. The lamellæ are, at first, not visible, but later become distinct and more refractive just before gelatinization. The grain is more refractive, the first part to show this change is a band of starch at the margin which is broad at the distal end. Gelatinization begins at the distal margin and at the ends of any projections from the grain and progresses according to two methods. In the first, which is seen in the great majority of the grains, gelatinization begins at the proximal end shortly after the distal margin has been gelatinized, the hilum swelling suddenly and rapidly, and the bubble, if present, swelling also, then shrinking and disappearing. Gelatinization then advances from these two points, preceded by small cracks and fissures in the ungelatinized starch. Progress is more marked at the margin than elsewhere, and the marginal starch is all gelatinized before the central starch. Finally, only a small portion of the grain, which is just distal to the hilum, is ungelatinized, and this is split into 2 or 3 pieces which are widely separated and gelatinize independently of one another. In the second method, which is seen in a moderate number of the elongated grains, gelatinization begins at the distal end and progresses smoothly from this point toward the proximal end without any cracking or fissuring of the grain. The proximal portion is the last to be gelatinized. The gelatinized grains are much swollen, have rather thin capsules, and are much distorted, but show some resemblance to the form of the untreated grain.

The reaction with *chromic acid* begins in a few grains in 15 seconds; in about 76 per cent of the grains and 95 per cent of the total starch in 5 minutes; in 100 per cent of the grains and total starch in 15 minutes. (Chart D 554.)

The hilum becomes distinct in all the grains, rarely attended by the formation of a bubble which as the grain swells soon shrinks and disappears. The lamellæ become very distinct; gelatinization begins at the hilum and progresses according to two methods. In the first, which is seen in all the broad forms, which are also in the majority, 2 furrows or actual fissures are seen to extend transversely or slightly obliquely from the hilum on either side to the margin and the hilum begins to enlarge. The starch distal to these 2 fissures is first criss-crossed by many irregular fissures, then as the hilum and the grain continue to enlarge it is split into 3 or 4 pyramidal masses by wedge-shaped fissures and the starch in these pyramids eventually forms an irregularly granular mass just proximal to a broad, smooth band at the distal margin. The hilum meanwhile has been enlarging, especially toward the proximal end, and the starch here and at the sides nearby forms at the margin a thick, homogeneous-looking, refractive band which becomes thinner and hyaline in appearance, especially at the proximal apex. The capsule is dissolved at this point, and the grain dissolves from this region distally, the last part to be dissolved is often the granular mass at the distal end as before described. In the second method, which is seen in the elongated grains that are in the minority, the hilum begins to enlarge and 2 furrows or fissures extend obliquely from either side of the hilum quite to the distal margin. In some of the grains the part of the grain included between these fissures becomes irregularly fissured nearly to the distal margin where, however, a broad band of starch remains undisturbed. In others the portion proximal to this broad band is not irregularly fissured, but divided into filaments by fissures which slant proximally from the 2 original furrows or fissures on either side to the longitudinal axis of the grain. As the hilum continues to enlarge, a part of the fissured portion is gelatinized and the rest forms an irregularly granular mass just above the broad band of starch at the distal margin. The starch at the proximal end and sides forms a thick, homogeneous-looking band which is thinner at the proximal apex. It is dissolved at this point, dissolution proceeding distally until the whole grain is in solution, the granular starch at the distal end being the last to be dissolved.

The reaction with *pyrogallic acid* begins in 30 seconds. Complete gelatinization occurs in about 30 per cent of the entire number of grains and 86 per cent of the total starch in 5 minutes; in about 68 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 90 per cent of the grains and 99 per cent of the total starch in 30 minutes. (Chart D 555.)

The hilum becomes very distinct, unattended by the formation of a bubble. The lamellæ become more distinct at first, but later are obscured. Gelatinization begins at the hilum and progresses according to two methods. The first is seen in the broad forms which constitute a majority of all the grains, the hilum begins to enlarge and 2 furrows are seen to extend obliquely, rarely transversely, from the hilum on either side to the margin, and the starch proximal to these furrows forms a homogeneous-looking, refractive band at the proximal

end and sides nearby; as the hilum enlarges it pushes this band outward at the proximal end, and the band grows narrower and more nearly transparent at this point; meanwhile the portion of the grain distal to the 2 furrows becomes divided by regular, radiating fissures. The lamellæ become very distinct and more refractive. This portion of the grain now begins to gelatinize, and as the grain swells it loses its lamellated appearance and becomes more refractive and more hyaline in appearance, then it is divided into 3 or 4 pyramidal masses by wedge-shaped fissures which gelatinize with moderate rapidity from their apices toward their bases. Finally, this distal starch forms a broad, very nearly transparent, granular mass at the distal margin. Meanwhile the thick, homogeneous, refractive band at the proximal end and sides has been growing thinner and more hyaline, especially at the proximal end. It is finally gelatinized before the granular mass at the distal end, which slowly gelatinizes accompanied by considerable distortion of the capsule of the distal end. The second method is observed in the elongated grains. The hilum begins to swell and 2 fissures are seen to extend obliquely from either side of the hilum toward the distal margin. The proximal starch and that outside of the 2 fissures forms at the margin a thick, very refractive, homogeneous-looking band, which is pushed outward and becomes very thin at the proximal end as the hilum swells. In the starch comprehended between the 2 fissures, the lamellæ become at first very distinct, then fade as the starch becomes more hyaline in appearance; next this starch is divided by 2 rows of fissures which slant upward from the sides and meet in the line of the longitudinal axis of the grain. The fissures increase in size as the grain continues to swell and separate off successive filaments of starch, the inner ends of which are free but the outer ends attached along the line of the 2 original fissures. This process continues until the distal end is nearly reached, and there the starch, instead of being fissured, forms a broad, rather granular mass at the margin. The filaments which have been separated are meanwhile rapidly gelatinized. The marginal starch at the proximal end and side rather slowly gelatinizes and finally the granular mass at the distal end, with some distortion of the capsule at the latter point. The gelatinized grains are very much swollen, have rather thick capsules, and are considerably distorted, especially at the distal end, but retain some resemblance to the form of the untreated grain.

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 97 per cent of the entire number of grains and 98 per cent of the total starch in 15 seconds; in about 98 per cent of the grains and 99 per cent of the total starch in 30 seconds. (Chart D 556.)

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 90 per cent of the entire number of grains and 95 per cent of the total starch in 30 seconds; in about 99 per cent of the grains and in more than 99 per cent of the total starch in 45 seconds. (Chart D 557.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 94 per cent of the entire number of grains and 99 per cent of the total starch in 30 seconds. (Chart D 558.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 97 per cent of the entire number of grains and 98 per cent of the total starch in 15 seconds; in more than 99 per cent of the grains and total starch in 30 seconds. (Chart D 559.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 85 per cent of the entire number of grains and 98 per cent of the total starch in 1 minute; in about 98 per cent of the grains and in more than 99 per cent of the total starch in 3 minutes; in 99 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 560.)

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 80 per cent of the entire number of grains and 96 per cent of the total starch in 30 seconds; in about 98 per cent of the grains and in more than 99 per cent of the total starch in 1 minute. (Chart D 561.)

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 97 per cent of the entire number of grains and 98 per cent of the total starch in 15 seconds; in more than 99 per cent of the grains and total starch in 30 seconds. (Chart D 562.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 98 per cent of the entire number of grains and 99 per cent of the total starch in 30 seconds; in more than 99 per cent of the grains and total starch in 1 minute. (Chart D 563.)

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 80 per cent of the entire number of grains and 96 per cent of the total starch in 30 seconds; in about 96 per cent of the grains and in more than 99 per cent of the total starch in 1 minute. (Chart D 564.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 66 per cent of the entire number of grains and 75 per cent of the total starch in 3 minutes; in about 80 per cent of the grains and 95 per cent of the total starch in 5 minutes; in about 99 per cent of the grains and in more than 99 per cent of the total starch in 10 minutes. (Chart D 565.)

The hilum becomes distinct, attended by the formation of a bubble in very few grains. The lamellæ are at first invisible but gradually become distinct in most of the grains. The grains become more refractive; the first part of the grain to show this is a band of starch at the margin which is broader at the distal end than elsewhere. Gelatinization begins at the distal margin and progresses according to but one method. Gelatinization advances toward the hilum, preceded by an indistinctly granular or pitted appearance of the surface of the grain. The central portion of the grain is apparently the less resistant to the reagent, as a broad refractive canal is seen to extend through the center to the hilum, and the bubble if present swells, shrinks, and disappears before there is any indication on the surface of the grain that the hilum is reached. Shortly the starch in the central portion swells, splitting the ungelatinized material into two pieces which are widely separated and gelatinize independently of one another. In some grains gelatinization

begins first at the distal and then at the proximal end, but the progress of gelatinization is the same as that described. The gelatinized grains are much swollen, have rather thin capsules, and are very much distorted, retaining none of the form of the untreated grain.

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 81 per cent of the entire number of grains and 95 per cent of the total starch in 1 minute; in more than 99 per cent of the grains and total starch in 5 minutes. (Chart D 566.)

The reaction with *uranium nitrate* begins in 15 seconds. Complete gelatinization occurs in about 66 per cent of the entire number of grains and 84 per cent of the total starch in 1 minute; in about 97 per cent of the grains and in more than 99 per cent of the total starch in 3 minutes; in more than 99 per cent of the grains and total starch in 5 minutes. (Chart D 567.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 90 per cent of the entire number of grains and 95 per cent of the total starch in 1 minute; in more than 99 per cent of the total starch in 3 minutes. (Chart D 568.)

The reaction with *cobalt nitrate* begins in 30 seconds. Complete gelatinization occurs in about 85 per cent of the entire number of grains and 98 per cent of the total starch in 5 minutes; in about 96 per cent of the grains and in more than 99 per cent of the total starch in 15 minutes. (Chart D 569.)

The hilum becomes distinct, unaccompanied by the formation of a bubble. The lamellæ also become distinct. Gelatinization begins at the hilum and progresses according to two methods. In the first, which is seen in all the broader grains which are in the majority, 2 furrows are observed to extend transversely or slightly obliquely from the hilum on either side to the margin. That part of the grain which is distal to these furrows and to the hilum becomes more refractive in appearance, accompanied by a greater distinctness of the lamellæ, and is then divided by very fine fissures radiating from the hilum. Meanwhile that part of the grain proximal to the hilum and the furrows becomes homogeneous-looking and very refractive. The hilum now begins to enlarge steadily, apparently more toward the proximal than toward the distal end, and the proximal starch and that of the sides nearby forms a thick, homogeneous-looking band at the proximal margin which just at the apex is thinner and more hyaline in appearance than elsewhere. The distal starch forms a broad granular mass at the distal end. That portion just at the margin, however, is not granular and is homogeneous-looking. This latter portion is the first to be completely gelatinized, then the band at the proximal end and sides nearby, and finally the granular mass near the distal margin. In the second method, which is seen in the elongated grains, the hilum enlarges somewhat and 2 furrows or fissures are seen to extend obliquely from either side of the hilum nearly to or quite to the distal margin. The starch comprehended between these 2 furrows grows more refractive and is then divided into filaments or bundles of filaments from the hilum nearly to the margin by 2 rows of fissures, slanting proximally from the original furrows or fissures, to the longitudinal axis of the grain. These filaments are partially gelatinized and leave a granular residue which collects just above the starch at the distal end. This starch at the distal end is rather indistinctly fissured by parallel longitudinal fissures and is then gelatinized, becoming slowly thinner and more hyaline in the process. The starch at the proximal end and sides meanwhile forms a thick, homogeneous-looking, marginal band, and as the hilum swells and enlarges in the direction of the proximal end more than toward the distal end, the starch at the proximal apex becomes thinner and more hyaline in appearance. The starch at the distal margin gelatinizes first, then that at the proximal margin and sides, and finally that composing the granular mass near the distal end. The gelatinized grains are much swollen, have rather thin capsules, and are considerably distorted, especially at the distal end. They, however, retain some resemblance to the form of the untreated grain.

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 78 per cent of the entire number of grains and 86 per cent of the total starch in 30 seconds; in about 92 per cent of the grains and in more than 99 per cent of the total starch in 1 minute. (Chart D 570.)

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 67 per cent of the entire number of grains and 87 per cent of the total starch in 1 minute; in about 96 per cent of the grains and in more than 99 per cent of the total starch in 3 minutes; in more than 99 per cent of the grains and total starch in 5 minutes. (Chart D 571.)

The reaction with *barium chloride* begins in 15 seconds. Complete gelatinization occurs in about 60 per cent of the entire number of grains and 74 per cent of the total starch in 5 minutes; in about 78 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 91 per cent of the grains and 98 per cent of the total starch in 30 minutes; very little if any further advance in 45 and 60 minutes. (Chart D 572.)

The reaction with *mercuric chloride* begins immediately. Complete gelatinization occurs in about 57 per cent of the entire number of grains and 68 per cent of the total starch in 1 minute; in 86 per cent of the grains and 97 per cent of the total starch in 3 minutes; in about 95 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 573.)

Musa Gilletii (Pollen Parent).

(Plate 23, fig. 134; Charts D 553 to D 573.)

Histologic Properties.

In *form* the grains are usually simple and isolated, there being a few compound grains and a few aggregates. The compound grains belong to two types instead of but one as in *M. arnoldiana:* (1) 2 small or common-sized grains surrounded by 2 or 3 common secondary lamellæ; (2) 3 or more very small grains surrounded by 20 or 30 common secondary lamellæ. The aggregates, of which none was seen in *N. arnoldiana,* each consists of 2 grains of equal size adherent at their distal ends or at the distal end of one and the side of the other, or of 3 or more equal-sized grains arranged in an irregularly linear manner. The grains are, as in *M. arnoldiana,* moderately regular in form, and any irregularities are due to the following causes: (1) A deviation of the longitudinal axis (usually near the distal end) and a consequent bending of the grain; (2) small nipple-like or larger pointed projections from the proximal end;

(3) a secondary set of lamellæ whose longitudinal axis is at an angle, usually of 90°, with that of the primary set; (4) a greater development of one part of the distal end than of the rest. The conspicuous form is the elliptical which is usually rather slender and has a flattened distal end, but which may be broad and have both ends rounded. The additional forms are triangular with curved base and rounded angles, ovoid, round and nearly round, pyriform, quadrilateral with rounded corners, polygonal, finger-shaped, and oyster-shell-shaped. There are many more elongated forms than in *M. arnoldiana*, and hence the grains are not so often flattened as in that species; but all the broader forms are flattened, and when viewed on edge have an irregular rod-shape. Many of the grains of this specimen have a crushed appearance and some of them are eroded at the sides and distal margin.

The *hilum* is as distinct as in *M. arnoldiana*, and is a round or lenticular-shaped spot which in the majority of the grains is not fissured. It is fissured somewhat more often than in *M. arnoldiana* and the fissures have the following forms: (1) A single, straight or curved line which may be transverse or oblique; (2) an irregularly stellate arrangement of fissures; (3) cruciate-, T- or Y-shaped; (4) flying-bird shape. The hilum is eccentric from 0.4 to 0.2, usually 0.24, of the longitudinal axis. The degree of eccentricity is less than in some grains of *M. arnoldiana*, but, on the whole, it is about the same.

The *lamellæ* are often more distinct but not so fine as those of *M. arnoldiana*. Near the hilum and in the proximal one-third of the grains they are regular, round or oval, continuous rings. In the rest of the grain they have in general the form of the contour of the grain, but are often wavy and somewhat irregular in outline. Near the distal end they are not so fine and become discontinuous. There are, as in *M. arnoldiana*, one or more coarse refractive lamellæ which divide the fine lamellæ into bands of varying breadth. The number counted on the larger grains varies from 15 to 30, commonly 24, which is less than in *M. arnoldiana*.

In *size* the grains vary from the smaller which are 6 by 6μ, to the larger which are 50 by 34μ, in length and breadth. The common-sizes are 34 by 30μ and 32 by 22μ, which is slightly larger than in *M. arnoldiana*.

Polariscopic Properties.

The *figure* is more distinct and more often well defined than in *M. arnoldiana*. The lines sometimes cross at right angles or, as in *M. arnoldiana*, at acute angles of widely varying size. They are not so often bent or bisected as in *M. arnoldiana*.

The *degree of polarization* varies from low to high (value 45), slightly higher than in *M. arnoldiana*. There are more grains in which it is moderate, and fewer in which it is low, than in *M. arnoldiana*. There is also not so much variation in a given aspect of an individual grain.

With *selenite* the quadrants are more often clear-cut and less unequal in size and irregular in shape than in *M. arnoldiana*. The colors also are somewhat more often pure than in that starch.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate blue-violet (value 50), somewhat less than in *M. arnoldiana*. The color deepens very rapidly until it is very deep and more bluish in tint. With 0.125 per cent Lugol's solution the grains all color a light to moderate blue-violet, less than in *M. arnoldiana*, and less in some grains than in others. The color deepens very rapidly until it is very deep and more bluish. After heating in water until all the grains are gelatinized and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* all color a light to moderate indigo, more than in *M. arnoldiana;* and the *solution* a deep indigo, but less than in *M. arnoldiana*. If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, the *grain-residues* color a light indigo, more than in *M. arnoldiana;* the *capsules* a red or reddish violet as in this species and the *solution* a very deep indigo as in this starch.

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes they are lightly to deeply colored (value 45), less than in *M. arnoldiana*. More of the grains are lightly and fewer deeply colored than in *M. arnoldiana*.

With *safranin* the grains all color very lightly at once, and in 30 minutes they are lightly to deeply colored (value 50), less than in *M. arnoldiana*. There are more lightly colored and fewer deeply colored grains than in *M. arnoldiana*.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 64° to 66.5° C., and of all 67.5° to 69° C., mean 68.4° C., or 3.4° higher than in *M. arnoldiana*.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in 1 minute. Complete gelatinization occurs in about 17 per cent of the entire number of grains and 30 per cent of the total starch in 5 minutes; in about 52 per cent of the grains and 69 per cent of the total starch in 15 minutes; in about 65 per cent of the grains and 78 per cent of the total starch in 30 minutes; in about 78 per cent of the grains and 88 per cent of the total starch in 45 minutes; in about 88 per cent of the grains and 95 per cent of the total starch in 60 minutes. (Chart D 553.)

The hilum becomes distinct, attended by the formation of a bubble in a majority of the grains, many more than in *M. arnoldiana*. The lamellæ are at first not visible, but later become more distinct than in *M. arnoldiana*. The grains, as in *M. arnoldiana*, become more refractive after the addition of the reagent, and the first portion of the grain to show this is a band of starch at the margin which is broader at the distal end than elsewhere. Gelatinization begins at the distal margin and follows the two methods described under *M. arnoldiana*. That seen in a majority of the grains is the same as was found in a minority of the elongated grains of *M. arnoldiana;* and that noted in the comparatively few broad forms is the same as that described for the majority of the grains of *M. arnoldiana*. The gelatinized grains are more swollen, do not have such thin capsules, and are not so much distorted, as in *M. arnoldiana*.

The reaction with *chromic acid* begins in a few grains in 15 seconds. Complete gelatinization occurs in about 40 per cent of the entire number of grains and 70 per cent of the total starch in 5 minutes; in about

77 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 97 per cent of the grains and in more than 99 per cent of the total starch in 30 minutes. (Chart D 554.)

The hilum and the lamellæ are more distinct than in *M. arnoldiana.* Gelatinization begins at the hilum and progresses according to the two methods seen in *M. arnoldiana.* The method noted in the elongated grains, which are in the majority in this starch, varies somewhat from that found in the elongated grains of *M. arnoldiana.* The method in this starch is as follows: 2 fissures or furrows are seen to extend obliquely from the hilum on either side, half the distance from the hilum to the distal margin. The starch between these 2 fissures is separated into filaments or bundles of filaments by a double row of fissures which slant proximally from the 2 original furrows or fissures to the longitudinal axis of the grain. The starch just proximal to the hilum and on the sides is divided into a number of coarse granules by regular radiating cracks or fissures. The rest of the starch at the proximal end and sides forms a thick homogeneous, refractive-looking marginal band and that at the distal end forms a broad refractive, rather thin band. The grain swells and the starch which is divided into filaments is partially gelatinized, leaving a granular residue. These granules in conjunction with those proximal to the hilum form a granular ring within the homogeneous ring just described. The outer homogeneous ring grows broader and more nearly transparent and is finally dissolved, usually at the distal end first, but in some grains at the side first. The granular ring, although it grows more and more hyaline, is dissolved later, and it also dissolves first at the distal end. In the second method, which is seen in a minority of the grains which are also those of broad forms, there are no differences noted between this starch and that of *M. arnoldiana.*

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 11 per cent of the total starch in 5 minutes; in about 11 per cent of the grains and 54 per cent of the total starch in 15 minutes; in about 42 per cent of the grains and 73 per cent of the total starch in 30 minutes; in about 61 per cent of the grains and 81 per cent of the total starch in 45 minutes; in about 63 per cent of the grains and 84 per cent of the total starch in 60 minutes. (Chart D 555.)

The hilum and the lamellæ both become more distinct than in *M. arnoldiana.* Gelatinization begins at the hilum and progresses according to two methods which are very similar to those described under *M. arnoldiana.* The method which is seen in the majority of the grains is similar to that noted in a minority of the grains of *M. arnoldiana.* The hilum swells slightly and 2 fissures extend obliquely on either side toward the distal margin, but do not penetrate as near it as in *M. arnoldiana.* The starch comprehended between these fissures is divided immediately into filaments or bundles of filaments by 2 rows of fissures which slant proximally from the 2 original furrows or fissures toward the longitudinal axis of the grain. Only a small part of the starch distal to the hilum is gelatinized in this way, which is a variation from that of *M. arnoldiana* in which the greater part of the distal starch was so gelatinized; the rest of the starch to the distal margin becomes increasingly hyaline and shrinks in a way that suggests that the less resistant starch was being gelatinized. Finally it forms a broad, very granular and irregular mass at the distal margin which is later gelatinized with much distortion of the capsule. The starch proximal to the hilum and outside the 2 original oblique furrows or fissures forms a homogeneous-looking, refractive band, with the exception of that portion which immediately surrounds the hilum. This is divided into coarse granules by short fissures at regular intervals. No such phenomenon is seen in *M. arnoldiana.* As the marginal band gradually becomes thinner and more hyaline in appearance, these granules grow thinner and more hyaline also, but are often the last part of the grain to be gelatinized. The second method which is seen in a minority of the grains is very nearly the same as that which has been described for a majority of the grains of *M. arnoldiana.* The only differences noted are that the starch distal to the 2 longitudinal fissures and the hilum becomes more nearly homogeneous in appearance and is not divided into pyramidal masses by wedge-shaped fissures, but merely grows gradually less in amount, and finally forms a broader and somewhat more irregularly granular mass at the distal margin. The gelatinized grains are as much swollen, have thicker capsules, and are even more distorted, especially at the distal end, than in *M. arnoldiana.*

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 52 per cent of the entire number of grains and 67 per cent of the total starch in 15 seconds; in about 68 per cent of the grains and 80 per cent of the total starch in 30 seconds; in about 73 per cent of the grains and 90 per cent of the total starch in 5 minutes; in about 80 per cent of the grains and 93 per cent of the total starch in 15 minutes; in about the same percentage of the grains and 96 per cent of the total starch in 30 minutes. (Chart D 556.)

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 70 per cent of the entire number of grains and 75 per cent of the total starch in 30 seconds; in about 90 per cent of the grains and 93 per cent of the total starch in 45 seconds; in 95 per cent of the grains and 96 per cent of the total starch in 1 minute. (Chart D 557.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in more than 58 per cent of the entire number of grains and 85 per cent of the total starch in 30 seconds; in about 77 per cent of the grains and 93 per cent of the total starch in 1 minute; in about 88 per cent of the grains and 98 per cent of the total starch in 3 minutes; in about 91 per cent of the grains and 99 per cent of the total starch in 5 minutes. (Chart D 558.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 73 per cent of the entire number of grains and 81 per cent of the total starch in 15 seconds; in about 81 per cent of the grains and 93 per cent of the total starch in 30 seconds; in about 84 per cent of the grains and 95 per cent of the total starch in 1 minute. (Chart D 559.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 50 per cent of the entire number of grains and 75 per cent of the total starch in 1 minute; in about 60 per cent of the grains and 85 per cent of the total starch in 3 minutes;

in about 66 per cent of the grains and 87 per cent of the total starch in 5 minutes; in about 82 per cent of the grains and 96 per cent of the total starch in 15 minutes. (Chart D 560.)

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 9 per cent of the entire number of grains and 14 per cent of the total starch in 30 seconds; in about 65 per cent of the grains and 87 per cent of the total starch in 1 minute; in about 85 per cent of the grains and 97 per cent of the total starch in 3 minutes; in about 95 per cent of the grains and in more than 99 per cent of the total starch in 15 minutes. (Chart D 561.)

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 18 per cent of the entire number of grains and 27 per cent of the total starch in 15 seconds; in about 55 per cent of the grains and 70 per cent of the total starch in 30 seconds; in about 74 per cent of the grains and 95 per cent of the total starch in 5 minutes; in about 85 per cent of the grains and 97 per cent of the total starch in 15 minutes. (Chart D 562.)

(Observations at 15 and 30 seconds are taken for comparison with *M. arnoldiana*. The changes are very slight after 15 minutes. Most of those which are ungelatinized will probably remain for 60 minutes.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 43 per cent of the entire number of grains and 65 per cent of the total starch in 30 seconds; in about 69 per cent of the grains and 84 per cent of the total starch in 1 minute; in about 87 per cent of the grains and 95 per cent of the total starch in 5 minutes; in about 91 per cent of the grains and 98 per cent of the total starch in 15 minutes. (Chart D 563.)

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 18 per cent of the total starch in 30 seconds; in about 33 per cent of the grains and 42 per cent of the total starch in 1 minute; in about 56 per cent of the grains and 81 per cent of the total starch in 5 minutes; in about 76 per cent of the grains and 89 per cent of the total starch in 15 minutes; in about 81 per cent of the grains and 95 per cent of the total starch in 30 minutes. (Chart D 564.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 49 per cent of the entire number of grains and 74 per cent of the total starch in 3 minutes; in about 74 per cent of the grains and 85 per cent of the total starch in 5 minutes; in about 90 per cent of the grains and 95 per cent of the total starch in 10 minutes; in about 98 per cent of the grains and 99 per cent of the total starch in 15 minutes. (Chart D 565.)

The hilum becomes distinct, attended by the formation of a bubble in a majority of the grains, many more than in *M. arnoldiana*. The lamellæ are at first invisible, but gradually become more distinct than in *M. arnoldiana*. The grains become as refractive as in *M. arnoldiana* on the addition of the reagent, and the first portion to show this change is a band of starch at the margin which is broader at the distal end than elsewhere. Gelatinization begins at the distal margin and progresses according to two methods. The first which is noted in a majority of the grains is not seen in *M. arnoldiana*. Gelatinization preceded by a pitted appearance of the surface of the grain advances smoothly from the distal margin toward the hilum and proximal end, when the hilum is reached it swells, and the bubble, if present, swells, shrinks, and finally disappears, and the proximal starch which has become more refractive is rapidly gelatinized. The second method, which is seen in a minority of the grains, is the same as that described for all the grains of *M. arnoldiana*. The gelatinized grains are more swollen, do not have such thin capsules, and are not so much distorted as in *M. arnoldiana*.

The reaction with *calcium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 10 per cent of the total starch in 1 minute; in about 60 per cent of the grains and 80 per cent of the total starch in 5 minutes; in about 70 per cent of the grains and 86 per cent of the total starch in 15 minutes; in about 72 per cent of the grains and 90 per cent of the total starch in 30 minutes; slight advance in 45 minutes; in about 76 per cent of the grains and 93 per cent of the total starch in 60 minutes. (Chart D 566.)

The reaction with *uranium nitrate* begins in a few grains in 15 seconds. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 10 per cent of the total starch in 1 minute; in about 47 per cent of the grains and 77 per cent of the total starch in 3 minutes; in about 53 per cent of the grains and 80 per cent of the total starch in 5 minutes; in about 70 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 73 per cent of the grains and 93 per cent of the total starch in 30 minutes; in about 77 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 80 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 567.)

The reaction with *strontium nitrate* begins in a few grains in 30 seconds. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 14 per cent of the total starch in 1 minute; in about 63 per cent of the grains and 83 per cent of the total starch in 3 minutes; in about 65 per cent of the grains and 87 per cent of the total starch in 5 minutes; in about 81 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 87 per cent of the grains and 97 per cent of the total starch in 30 minutes; little if any further advance is observed in 45 and 60 minutes, respectively. (Chart D 568.)

The reaction with *cobalt nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 7 per cent of the entire number of grains and 14 per cent of the total starch in 5 minutes; in about 18 per cent of the grains and 28 per cent of the total starch in 15 minutes; in about 25 per cent of the grains and 38 per cent of the total starch in 30 minutes; in about 35 per cent of the grains and 48 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 52 per cent of the total starch in 60 minutes. (Chart D 569.)

The hilum and the lamellæ are both more distinct than in *M. arnoldiana*. Gelatinization begins at the hilum and progresses according to the two methods described under *M. arnoldiana*. The method which is seen in the

elongated grains, which are in the majority in this starch, is very similar to that seen in the elongated grains of *M. arnoldiana,* which are in the minority in that starch. The differences noted are that the 2 furrows or fissures from the hilum do not extend so close to the distal margin, but usually only half of the way between the hilum and the margin. The starch comprehended between the 2 fissures is fissured and separated into filaments as in *M. arnoldiana,* but the rest of the distal starch is irregularly fissured nearly to the margin. The proximal starch and that at the sides forms a homogeneous-looking, refractive band, except that immediately surrounding the hilum, which is broken up by short regular cracks into coarse granules. These granules, and those left as a residue after the filaments of starch distal to the hilum are gelatinized, are the most resistant part of the grain. The distal starch gelatinizes first, then the homogeneous-looking, marginal band at the proximal end and sides, then granules at the distal end, and finally those at the proximal end. In the second method there are no differences noted. The gelatinized grains are more swollen, have somewhat thicker capsules, and are more distorted at the proximal end than in *M. arnoldiana.*

The reaction with *copper nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 5 per cent of the total starch in 30 seconds; in about 5 per cent of the grains and 16 per cent of the total starch in 1 minute; in about 45 per cent of the grains and 72 per cent of the total starch in 5 minutes; in about 68 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 90 per cent of the grains and 98 per cent of the total starch in 30 minutes; very little if any further advance in 45 and 60 minutes, respectively. (Chart D 570.)

The reaction with *cupric chloride* begins in a few grains in 15 seconds. Complete gelatinization occurs in 1 per cent of the entire number of grains and 10 per cent of the total starch in 1 minute; in about 32 per cent of the grains and 55 per cent of the total starch in 3 minutes; in about 35 per cent of the grains and 60 per cent of the total starch in 5 minutes; in about 52 per cent of the grains and 79 per cent of the total starch in 15 minutes; in about 61 per cent of the grains and 84 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 85 per cent of the total starch in 45 minutes; in about 63 per cent of the grains and 89 per cent of the total starch in 60 minutes. (Chart D 571.)

The reaction with *barium chloride* begins in a few grains in 30 seconds. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 32 per cent of the grains and 51 per cent of the total starch in 15 minutes; in about 35 per cent of the grains and 56 per cent of the total starch in 30 minutes; little if any further advance occurs in 45 and 60 minutes, respectively. (Chart D 572.)

The reaction with *mercuric chloride* begins in a few grains in 30 seconds. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 10 per cent of the total starch in 1 minute; in about 23 per cent of the grains and 39 per cent of the total starch in 3 minutes; in about 32 per cent of the grains and 54 per cent of the total starch in 5 minutes; in about 42 per cent of the grains and 61 per cent of the total starch in 15 minutes; in about 46 per cent of the grains and 71 per cent of the total starch in 30 minutes; in about 50 per cent of the grains and 75 per cent of the total starch in 45 minutes; in about 55 per cent of the grains and 79 per cent of the total starch in 60 minutes. (Chart D 573.)

MUSA HYBRIDA (HYBRID).

(Plate 23, fig. 135; Charts D 553 to D 573.)

HISTOLOGIC PROPERTIES.

In *form* the grains are usually simple and isolated, there being few compound grains and an occasional aggregate. The compound grains belong to the two types described under *M. gilletii.* The aggregates consist of the types described under *M. gilletii,* and also of a type composed of 12 or more small grains in the form of an irregularly spherical mass. The grains are as moderately regular in form as in *M. gilletii,* and any irregularities are due to the following causes, which are the same as in *M. gilletii:* (1) A deviation of the longitudinal axis of the grain near the center or near the distal end, with a consequent curvature of the grain; (2) small nipple-like or larger pointed projections from the proximal end; (3) a secondary set of lamellæ whose longitudinal axis is at an angle, usually a right angle, with that of the primary set; (4) a greater development of one part of the distal margin than of the rest of the grain. The conspicuous forms are the elliptical, usually slender with flattened distal end, but sometimes broad with both ends rounded, and ovoid usually with a flattened distal end. The additional forms are triangular with curved base and rounded angles, round and nearly round, pyriform, and quadrilateral with rounded angles. Some of the grains of this specimen are crushed and eroded, as in the parents.

Most of the grains of the hybrid are, as in *M. gilletii,* not flattened; but the broader forms are flattened, and when viewed on edge have an irregularly rod-like form, as in both parents.

In form the grains of *M. hybrida* show a much closer relationship to *M. gilletii* than to *M. arnoldiana,* exhibiting characteristics of each and both, and also certain individualities.

The *hilum* is as distinct as in both parents and is more frequently fissured than in either parent, in this characteristic resembling *M. gilletii* more than *M. arnoldiana.* The fissures have the following forms which are the same as in *M. gilletii:* (1) A single, straight or curved line placed transversely or obliquely; (2) an irregularly stellate arrangement of several fissures; (3) cruciate-, T- or Y-shaped; (4) flying-bird shape. The hilum is eccentric from 0.42 to 0.2, usually 0.23, of the longitudinal axis, about the same as in the parents. In the character and eccentricity of the hilum *M. hybrida* shows a closer relationship to *M. gilletii* than to *M. arnoldiana.*

The *lamellæ* are, as in *M. gilletii,* rather fine, distinct rings which are continuous near the hilum but discontinuous at or near the distal end. In character and arrangement they are essentially the same as in *M. gilletii.* The number counted on the larger grains varies from 12 to 34, usually 28, nearly the same as in *M. arnoldiana* and more than in *M. gilletii.*

In the character and the arrangement of the lamellæ *M. hybrida* shows a very much closer relationship to *M. gillelii* than to *M. arnoldiana,* but in number the reverse.

In *size* the grains vary from the smaller which are 5 by 5μ, to the larger which are 60 by 34μ, in length and breadth. The common sizes are 34 by 22μ and 34 by 30μ. In size the grains of *M. hybrida* are much closer to those of *M. gillelii* than of *M. arnoldiana,* but they may be larger than the grains of either parent.

Polariscopic Properties.

The *figure* is as distinct and as well defined as in *M. gilletii.* The lines, as in *M. gillelii,* sometimes cross at right angles or at acute angles of varying degree. They are not more often bent or bisected than in *M. gilletii.*

The *degree of polarization* varies from low to high (value 50), more than in either parent, but nearer to *M. gilletii* than to *M. arnoldiana.* There are more grains with a high degree of polarization and there is less variation in a given aspect of an individual grain than in either parent.

With *selenite* the quadrants as in *M. gillelii* are often clean-cut and are unequal in size, but not often irregular in shape. The colors are somewhat more often pure than in *M. gilletii* and much more often than in *M. arnoldiana.*

In the character of the figure, the degree of polarization, and the appearances with selenite *M. hybrida* shows a closer relationship to *M. gilletii* than to *M. arnoldiana.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains all color a moderate blue-violet (value 50), the same as in *M. gilletii.* With 0.125 per cent Lugol's solution the grains all color lightly to moderately as in *M. gillelii,* some more than others. After heating in water until all the grains are gelatinied and then treating with a 2 per cent Lugol's solution, the gelatinized *grains* vary in color from a light to moderate indigo; and the *solution* is a deep indigo as in *M. gillelii.* If the preparation is boiled for 2 minutes and then treated with an excess of a 2 per cent Lugol's solution, many of the *grain-residues* color a light indigo, the *capsules* a red or a reddish violet, and the *solution* a very deep indigo as in *M. gilletii.* Qualitatively and quantitatively the reactions with iodine show a much closer relationship to *M. gilletii* than to *M. arnoldiana.*

Aniline Reactions.

With *gentian violet* the grains all color very lightly at once, and in 30 minutes they are lightly to deeply colored (value 45), the same as in *M. gillelii.*

With *safranin* the grains all color very lightly at once, and in half an hour they are lightly to deeply colored (value 50), the same as in *M. gilletii.*

In the reaction with aniline stains, *M. hybrida* shows a much closer relationship to *M. gilletii* than to *M. arnoldiana.*

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 65.2° to 67° C., and of all 69° to 70.5° C., mean 69.75° C. The temperature of gelatinization of *M. hybrida* is higher than that of either parent, but is much closer to *M. gilletii* (mean 68.4°) than to *M. arnoldiana* (mean 65°).

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in a few grains in 30 seconds. Complete gelatinization occurs in about 16 per cent of the entire number of grains and 28 per cent of the total starch in 5 minutes; in about 51 per cent of the grains and 58 per cent of the total starch in 15 minutes; in about 66 per cent of the grains and 73 per cent of the total starch in 30 minutes; in about 68 per cent of the grains and 70 per cent of the total starch in 45 minutes; in about 73 per cent of the grains and 77 per cent of the total starch in 60 minutes. (Chart D 553.)

The hilum becomes distinct, attended by the formation of a bubble in a great majority of the grains. More than in either parent. The hybrid in this characteristic is closer to *M. gilletii* than to *M. arnoldiana.* The lamellæ, as in *M. gillelii,* are at first invisible, but later become very distinct, especially just before gelatinization. Gelatinization begins at the distal margin and progresses according to the two types described for both parents. In the majority of the grains the process is that seen in a majority of the grains of *M. gilletii* and in a small minority of the grains of *M. arnoldiana.* The gelatinized grains are as much swollen, have capsules as thin, and are as much distorted, as in *M. gillelii.* In this reaction *M. hybrida* shows qualitatively a somewhat closer relationship to *M. gilletii* than to *M. arnoldiana.*

The reaction with *chromic acid* begins in a few grains in 15 seconds. Complete gelatinization occurs in about 16 per cent of the entire number of grains and 22 per cent of the total starch in 5 minutes; in about 54 per cent of the grains and 79 per cent of the total starch in 15 minutes; in about 88 per cent of the grains and 97 per cent of the total starch in 30 minutes. (Chart D 554.)

The hilum and lamellæ are as distinct as in *M. gilletii.* Gelatinization begins at the hilum and progresses according to the two methods described for both parents. The method which is seen in the elongated grains, which are also in a great majority, is in nearly all the same as that noted in the elongated grains of *M. gilletii,* but in some it is the same as that seen in the elongated grains of *M. arnoldiana.* The method found in the few broad forms is the same as in both parents. In this reaction *M. hybrida* shows, qualitatively, a closer relationship to *M. gilletii* than to *M. arnoldiana.*

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 14 per cent of the total starch in 5 minutes; in about 20 per cent of the grains and 55 per cent of the total starch in 15 minutes; in about 32 per cent of the grains and 73 per cent of the total starch in 30 minutes; slight progress in 45 minutes; in about 34 per cent of the grains and 79 per cent of the total starch in 60 minutes. (Chart D 555.)

The reaction is much less rapid than in *M. arnoldiana* and much nearer that of *M. gilletii;* at first the reaction is more rapid than in the latter species, but later it is more retarded. There appears to be two types of grains, one of which is much more easily gelatinized than the other.

The hilum and lamellæ are as distinct as in *M. gilletii* and more distinct than in *M. arnoldiana*. Gelatinization, as in both parents, begins at the hilum and progresses according to two methods. That seen in a very large majority of the grains is the same as that described for a somewhat smaller majority of the grains of *M. gilletii*. The second method is the same as that in a minority of the grains of *M. gilletii* and in a larger majority of the grains of *M. arnoldiana*, and is seen in only a few scattered grains. The gelatinized grains are as much swollen, have as thick capsules, and are as much distorted as in *M. gilletii*. In this reaction *M. hyrida* shows qualitatively a much closer relationship to *M. gilletii* than to *M. arnoldiana*.

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 33 per cent of the entire number of grains and 47 per cent of the total starch in 15 seconds; in about 45 per cent the grains and 59 per cent of the total starch in 30 seconds; in about 68 per cent of the grains and 90 per cent of the total starch in 5 minutes; in about 77 per cent of the grains and 93 per cent of the total starch in 15 minutes; in about the same percentage of the grains and 95 per cent of the total starch in 30 minutes. (Chart D 556.)

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 39 per cent of the entire number of grains and 48 per cent of the total starch in 30 seconds; in about 78 per cent of the grains and 87 per cent of the total starch in 45 seconds; in about 91 per cent of the grains and 95 per cent of the total starch in 1 minute. (Chart D 557.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 62 per cent of the entire number of grains and 84 per cent of the total starch in 30 seconds; in about 74 per cent of the grains and 89 per cent of the total starch in 1 minute; in about 87 per cent of the grains and 98 per cent of the total starch in 3 minutes; in about 91 per cent of the grains and 99 per cent of the total starch in 5 minutes. (Chart D 558.)

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 72 per cent of the entire number of grains and 81 per cent of the total starch in 15 seconds; in about 81 per cent of the grains and 91 per cent of the total starch in 30 seconds; in about 82 per cent of the grains and 95 per cent of the total starch in 1 minute. (Chart D 559.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 45 per cent of the entire number of grains and 62 per cent of the total starch in 1 minute; in about 52 per cent of the grains and 78 per cent of the total starch in 3 minutes; in about 58 per cent of the grains and 84 per cent of the total starch in 5 minutes; in about 75 per cent of the grains and 95 per cent of the total starch in 15 minutes. (Chart D 560.)

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 7 per cent of the entire number of grains and 12 per cent of the total starch in 30 seconds; in about 56 per cent of the grains and 81 per cent of the total starch in 1 minute; in about 81 per cent of the grains and 95 per cent of the total starch in 5 minutes; in about 92 per cent of the grains and 99 per cent of the total starch in 15 minutes. (Chart D 561.)

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 14 per cent of the entire number of grains and 20 per cent of the total starch in 15 seconds; in about 57 per cent of the grains and 64 per cent of the total starch in 30 seconds; in about 70 per cent of the grains and 92 per cent of the total starch in 5 minutes; in about 75 per cent of the grains and 95 per cent of the total starch in 15 minutes. (Chart D 562.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 28 per cent of the entire number of grains and 36 per cent of the total starch in 30 seconds; in about 48 per cent of the grains and 68 per cent of the total starch in 1 minute; in about 81 per cent of the grains and 93 per cent of the total starch in 5 minutes; in about 91 per cent of the grains and 97 per cent of the total starch in 15 minutes. (Chart D 563.)

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 8 per cent of the total starch in 30 seconds; in about 28 per cent of the grains and 38 per cent of the total starch in 1 minute; in about 43 per cent of the grains and 70 per cent of the total starch in 5 minutes; in about 66 per cent of the grains and 87 per cent of the total starch in 15 minutes; in about 75 per cent of the grains and 95 per cent of the total starch in 30 minutes. (Chart D 564.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 39 per cent of the entire number of grains and 62 per cent of the total starch in 3 minutes; in about 58 per cent of the grains and 73 per cent of the total starch in 5 minutes; in about 85 per cent of the grains and 90 per cent of the total starch in 10 minutes; in about 96 per cent of the grains and 98 per cent of the total starch in 15 minutes. (Chart D 565.)

The hilum becomes distinct, attended by the formation of a bubble in more grains than in either parent, in this respect the hybrid being closer to *M. gilletii* than to *M. arnoldiana*. The lamellæ are at first invisible, but later become as distinct as in *M. gilletii*. The grains, as in both parents, become more refractive after the addition of the reagent, and the first part of the grain to be so affected is a band of material at the margin which is broader at the distal end than elsewhere. Gelatinization, as in both parents, begins at the distal end and progresses according to the two methods described under *M. gilletii*, only one of which is seen in *M. arnoldiana*. The first of these methods, which is not seen in *M. arnoldiana*, is noted in an even greater majority of the grains than in *M. gilletii*. The gelatinized grains are as much swollen, have as thin capsules, and are as much distorted as in *M. gilletii*. In this reaction *M. hybrida* shows qualitatively a closer relationship to *M. gilletii* than to *M. arnoldiana*.

The reaction with *calcium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 8 per cent of the total starch in 1 minute; in about 44 per cent of the grains and 58 per cent of the total starch in 5 minutes; in about 61 per cent of the grains and 74 per

cent of the total starch in 15 minutes; in about 64 per cent of the grains and 80 per cent of the total starch in 30 minutes; in about 68 per cent of the grains and 86 per cent of the total starch in 45 minutes; in about 72 per cent of the grains and 90 per cent of the total starch in 60 minutes. (Chart D 566.)

The reaction with *uranium nitrate* begins in a few grains in 15 seconds. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 8 per cent of the total starch in 1 minute; in about 37 per cent of the grains and 54 per cent of the total starch in 3 minutes; in about 53 per cent of the grains and 73 per cent of the total starch in 5 minutes; in about 64 per cent of the grains and 83 per cent of the total starch in 15 minutes; in about 68 per cent of the grains and 87 per cent of the total starch in 30 minutes; in about 70 per cent of the grains and 93 per cent of the total starch in 45 minutes; in about 75 per cent of the grains and 95 per cent of the total starch in 60 minutes. (Chart D 567.)

The reaction with *strontium nitrate* begins in a few grains in 30 seconds. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 15 per cent of the total starch in 1 minute; in about 61 per cent of the grains and 72 per cent of the total starch in 3 minutes; in about 65 per cent of the grains and 76 per cent of the total starch in 5 minutes; in about 78 per cent of the grains and 92 per cent of the total starch in 15 minutes; in about 84 per cent of the grains and 95 per cent of the total starch in 30 minutes; very little if any further advance in 45 and 60 minutes, respectively. (Chart D 568.)

The reaction with *cobalt nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 10 per cent of the grains and 21 per cent of the total starch in 15 minutes; in about 14 per cent of the grains and 30 per cent of the total starch in 30 minutes; in about 30 per cent of the grains and 40 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 44 per cent of the total starch in 60 minutes. (Chart D 569.)

The hilum and lamellæ are as distinct as in *M. gilletii.* Gelatinization begins at the hilum and progresses according to the two methods seen in both parents. That which is seen in a very large majority of the grains is nearly the same as that seen in a somewhat smaller majority of *M. gilletii* and is similar to that seen in a minority of the grains of *M. arnoldiana.* The only difference noted between *M. gilletii* and the hybrid is that all the grains do not show granule formation around the hilum, but a few gelatinize as described under *M. arnoldiana.* In the second method, which is seen in very few grains, there are no differences between either parents or hybrid. The gelatinized grains are as much swollen, have as thick capsules, and are as much distorted, particularly at the distal end, as in *M. gilletii.* In this reaction *M. hybrida* shows qualitatively a closer relationship to *M. giletii* than to *M. anoldiana.*

The reaction with *copper nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 4 per cent of the total starch in 30 seconds; in about 2 per cent of the grains and 8 per cent of the total starch in 1 minute; in about 39 per cent of the grains and 59 per cent of the total starch in 5 minutes; in about 66 per cent of the grains and 88 per cent of the total starch in 15 minutes; in about 66 per cent of the grains and 90 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes. (Chart D 570.)

The reaction with *cupric chloride* begins in a few grains in 15 seconds. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 5 per cent of the total starch in 1 minute; in about 25 per cent of the grains and 50 per cent of the total starch in 3 minutes; in about 30 per cent of the grains and 55 per cent of the total starch in 5 minutes; in about 40 per cent of the grains and 70 per cent of the total starch in 15 minutes; in about 50 per cent of the grains and 80 per cent of the total starch in 30 minutes; in about 55 per cent of the grains and 82 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 85 per cent of the total starch in 60 minutes. (Chart D 571.)

The reaction with *barium chloride* begins in a few grains in 30 seconds. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 5 per cent of the total starch in 5 minutes; in about 21 per cent of the grains and 26 per cent of the total starch in 15 minutes; in about 23 per cent of the grains and 40 per cent of the total starch in 30 minutes; little if any further advance occurs in 45 and 60 minutes. (Chart D 572.)

The reaction with *mercuric chloride* begins in a few grains in 30 seconds. Complete gelatinization occurs in less than 0.5 per cent of the entire number of grains and 3 per cent of the total starch in 1 minute; in about 14 per cent of the grains and 31 per cent of the total starch in 3 minutes; in about 29 per cent of the grains and 48 per cent of the total starch in 5 minutes; in about 39 per cent of the grains and 55 per cent of the total starch in 15 minutes; in about 45 per cent of the grains and 62 per cent of the total starch in 30 minutes; in about 47 per cent of the grains and 68 per cent of the total starch in 45 minutes; in about 57 per cent of the grains and 72 per cent of the total starch in 60 minutes. (Chart D 573.)

14. PHAIUS.

This genus of ornamental terrestrial orchids includes about 15 species. There are many more hybrids than species. The specimens were obtained from Sander and Sons, St. Albans, England.

Starches from the pseudobulbs of the following parent-stocks and hybrid-stocks were studied:

42. *P. grandifolius* Lour. (*Bletia tankervilliæ* R. Br.) (seed parent), *R. wallichii* Lindl. (*P. grandifolius* Lindl.; *P. bicolor* Lindl.; *P. grandiflorus* Reichb. f.) (pollen parent), and *P. hybridus* (hybrid).

42. Starches of Phaius grandifolius, P. wallichii, and P. hybridus.

Phaius grandifolius (Seed Parent).

(Plate 23, fig. 136; Charts D 574 to D 594.)

Histologic Properties.

In *form* most of the grains are simple and isolated with the exception of a few which appear in aggregates of usually 2, rarely 3, components. Compound and semi-compound grains usually of 2, rarely of 3, components are occasionally observed. Well-defined pressure facets are not present. Most of the grains are regular, although irregularities such as the following are moderately frequent: (1) Either a small nipple-like excrescence or protuberance at or near the proximal end, the former sometimes inserted in a concave depression at this end; (2) a long, blunt extension at or near the proximal end; (3) shifting of the longitudinal axis, which is usually slight, rarely abrupt; (4) a spicule-like excrescence, sometimes refractive, at the proximal end; (5) a flared addition or excrescence, sometimes refractive, at the distal end; (6) a concave indentation either at the proximal or distal end; (7) slightly undulating margin; and (8) secondary lamellæ which are placed at varying angles with the primary set. The conspicuous forms are ovoid, often elongated, with broadened and squared distal end; pyriform with broadened distal end; triangular with rounded angles; and pure ovoid. Additional forms are urn-shaped with flared distal margin; spindle-shaped, pyriform with elongated proximal end, knob-, club-, boot-, and bottle-shaped; and grains of indefinite shape. The grains are flattened, some much more than others, and when viewed on edge are usually narrow ellipsoidal with squared distal end.

The *hilum* is often not demonstrable, but when observed is usually either a lenticular or round, non-refractive to slightly refractive spot, occasionally quite refractive. Either a small, longitudinal slit-like cavity, or a short, transverse cleft is rarely present at the hilum. One delicate, short fissure occasionally emerges from either side of the hilum and is directed obliquely toward the distal end, and rarely such fissures may be quite long and so deflected as to become parallel with each other. The range of eccentricity is about 0.16 to 0.024, commonly about 0.06 to 0.05, of the longitudinal axis.

The *lamellæ* are generally demonstrable throughout the entire grain, although they are less distinct and finer near the proximal end, with the exception of a narrow refractive band sometimes found at the distal margin, in which they are either very fine or indistinct. They can usually be detected directly around the hilum either as elliptical, meniscus-shaped or circular rings, but even in those close to the hilum the form becomes flattened on the distal side of this structure, so that over most of the grain they are slightly crescentic to straight, being parallel with each other and with the distal margin; rarely they follow the outline of the grain. Most of the lamellæ are fine to moderately fine, but occasional exceptions are found in which they are moderately coarse over the greater part of the grain. One very refractive lamella is frequently located at varying distances from the hilum; and in most of the much elongated grains the finer lamellæ are grouped between coarser refractive ones which vary in number according to the length of the grain. A narrow, refractive band is often found at the proximal end which extends bilaterally, usually for about one-half to two-thirds, occasionally the entire length, of the grain. A group of undulating lamellæ, either about the middle or nearer the distal margin, is occasionally observed. Secondary lamellæ are moderately often present; they are usually unilateral and more often located at right angles either to the distal end or to about the middle of the grain; occasionally bilaterally located at the pointed distal end, or unilateral and at right angles to the proximal end. The number on much elongated grains may reach about 150, but generally about 100 on the common large grains.

The *size* varies from the smaller grains which are about 5 by 4μ, to the larger which are 130 by 46μ, in length and breadth. The common size is about 74 by 40μ in length and breadth.

Polariscopic Properties.

The *figure* is usually very eccentric. The lines are fine and intersect obliquely, they are straight in most grains, but moderately often are slightly bent and sometimes bisected. A few double figures are present.

The *degree of polarization* is high to very high (value 85). Variation is found in the different grains, and is also often considerable in the same aspect of a given grain, a portion of one quadrant often showing much lower polarization than the other quadrants.

With *selenite* the quadrants are generally well defined, unequal in size, and often slightly irregular in shape. The blue is more often pure, although in many grains it may lack purity throughout at least 1 quadrant; the yellow is more often not pure throughout the quadrants. The impurity is indicated at both ends of the scale, a frequent orange tint to the yellow and an occasional purplish tint to the blue caused by a low degree of polarization, and either a greenish tinge or an iridescence caused by very high polarization.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains color a moderate blue-violet (value 50) at once, which deepens rapidly, becoming more blue. With 0.125 per cent Lugol's solution the grains color a light blue-violet, which deepens rapidly, becoming more blue. After heating in water until the grains are gelatinized and then adding 2 per cent Lugol's solution, the *grains* color a deep blue, many with reddish tint, and the *solution* a moderately deep blue. If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues*, which are very few in number, become a light to moderate blue with deep reddish tint, and the *capsules* a deep reddish-heliotrope to a wine-red.

Aniline Reactions.

With *gentian violet* the grains immediately color very lightly, and in half an hour they are moderate to deep in color (value 57), with a greater number of the former. The coarser refractive lamellæ stain a little more deeply than the other lamellæ and also occasionally the hilum is slightly deeper than other parts. The secondary sets of lamellæ and the refractive band sometimes present either at the distal margin or at the proximal margin, and about half of the lateral margins, color less deeply than the main body of the grain.

With *safranin* the grains immediately color lightly, but somewhat deeper than with gentian violet; in half an hour they stain moderately to deeply (value 60) with more of the former, but the color is somewhat deeper than with gentian violet. The variations in depth of coloring with this reagent are the same as with gentian violet, but the differences are more marked since the color is slightly deeper than with gentian violet.

Temperature Reactions.

The majority of the grains are gelatinized at 65° to 66° C., and of all but rare resistant grains at 68° to 69° C., mean 68.5° C. The most resistant grains are those of medium size, and the most resistant parts are the outermost marginal lamellæ of the proximal end and sides nearby of all grains.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in a few grains immediately. Complete gelatinization occurs in about 20 per cent of the entire number of grains and 30 per cent of the total starch in 5 minutes; in about 42 per cent of the grains and 50 per cent of the total starch in 15 minutes; in about 60 per cent of the grains and 65 per cent of the total starch in 30 minutes; in about 75 per cent of the grains and 79 per cent of the total starch in 45 minutes; little if any further progress or about 80 per cent of the total starch in 60 minutes. (Chart D 574.)

The hilum becomes very distinct, attended sometimes by the formation of a bubble. Two distinct lines, apparently fissures, extending from the hilum to the distal corners, and sometimes longitudinal folds or wrinkles, apparently in the capsule, extend from the hilum almost to the distal margin. The lamellæ become distinct, especially toward the distal end, and a very distinct refractive band, which is especially broad at the proximal end, quickly forms about the margin of the grain, in which the lamellæ have become still more distinct. Gelatinization usually begins first at the distal and subsequently at the proximal end. In grains with a set of secondary lamellæ it begins at the distal end of the secondary set, then at the proximal end, and finally at the distal end of the primary set. Rarely it begins at the proximal end and then shortly at the distal end. It proceeds from both ends toward the most resistant portion of the grain which is usually just distal to the hilum and is preceded always by a pitted appearance of the ungelatinized parts. Those grains which are very resistant develop several deep, cup-shaped cavities in the ungelatinized portions which after crumbling into many small pieces are gelatinized. The gelatinized grains are very large and much distorted and do not retain much of the form of the untreated grain.

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 30 per cent of the total starch in 5 minutes; in about 20 per cent of the grains and 70 per cent of the total starch in 15 minutes; in about 95 per cent of the grains and in more than 99 per cent of the total starch in 30 minutes. (Chart D 575.)

The hilum becomes distinct, but without an attendant formation of a bubble. The lamellæ, at first distinct, become obscured by the process of fissuring, and then appear very distinct as rows of granules disposed according to the original lamellar arrangement. A broad refractive band is formed about the margin of many grains, the band being broader at the proximal end, and often not present at the distal end. Gelatinization begins at the hilum which enlarges, and the part of the grain just proximal to the hilum rapidly gelatinizes, making a broad, canal-like opening to the capsule. From this beginning gelatinization proceeds by extensive spreading of fine irregular fissures from the hilum to the distal margin. By this means the grain, as a whole, is divided into coarse granules near the hilum and fine granules near the distal end, and this process is promoted by the invasion of the grain by fine fissures which penetrate the grain from the distal margin. As the granules are gelatinized, beginning with those at the proximal end, those more distally placed are found in rows according to the lamellar arrangement. In the meantime the capsule at the proximal end and also at several other points is dissolved, but the grain retains much of its form until the granules are reduced to a semi-fluid mass which escapes from the openings in the capsule, and the distal starch is the last to be so gelatinized and dissolved. Some resistant shreds of the capsule persist long after the rest of the grain has been dissolved, but finally these also are dissolved.

The reaction with *pyrogallic acid* begins in a few grains immediately. Complete gelatinization occurs only in rare grains, less than 0.5, and 6 per cent of the total starch in 5 minutes; in about 0.5 per cent of the entire number of grains and 34 per cent of the total starch in 15 minutes; in about 16 per cent of the grains and 50 per cent of the total starch in 30 minutes; in about 22 per cent of the grains and 58 per cent of the total starch in 45 minutes; in about 28 per cent of the grains and 67 per cent of the total starch in 60 minutes. (Chart D 576.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in 38 per cent of the entire number of grains and 72 per cent of the total starch in 1 minute; in about 78 per cent of the grains and 95 per cent of the total starch in 5 minutes; in about 87 per cent of the grains and 97 per cent of the total starch in 10 minutes; in about 94 per cent of the grains and over 99 per cent of the total starch in 15 minutes. (Chart D 577.)

The hilum swells and sometimes a bubble appears which may occasionally enlarge considerably. Gelatinization spreads rapidly through the mesial portion to the distal margin, a marginal border at the proximal end and sides usually being the most resistant. In some grains a small swelling appears, first at the proximal end, and the process then proceeds as above described.

The gelatinized grains are much swollen and distorted, the distal margin is usually telescoped, and the proximal end has sometimes a concave depression. The

distal end is usually more distorted than the proximal end. The gelatinized grains do not resemble the untreated grain.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 78 per cent of the entire number of grains and 93 per cent of the total starch in 1 minute; in about 95 per cent of the entire number of grains and 98 per cent of the total starch in 2 minutes; complete gelatinization (100 per cent) in 3 minutes. (Chart D 578.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 84 per cent of the entire number of grains and 96 per cent of the total starch in 1 minute; in about 92 per cent of the grains and over 99 per cent of the total starch in 2 minutes; these resistant parts gradually gelatinize in 3 and 4 minutes, complete gelatinization of all grains occurring in 5 minutes. (Chart D 579.)

The hilum becomes very distinct, attended by the formation of a bubble. The lamellæ appear very distinct. A very refractive band is formed about the margin, which is broad at the proximal end, and narrow at the distal, and in some grains is not visible. Gelatinization begins at the hilum which enlarges, the bubble shrinks and disappears, and the starch immediately surrounding it is divided into a number of coarse granules. The proximal starch, with the exception of the granules, is rapidly gelatinized and the proximal end of the grain swells suddenly. The rest of the grain is divided by fine radiating striæ, which later develop into fine fissures, into granules arranged in rows according to the lamellar structure, and as gelatinization proceeds they are pushed to the distal margin and there gelatinized. The granules at the proximal end persist long after the rest of the grain is gelatinized, but are finally also gelatinized. The gelatinized grains are large and very nearly transparent and very thin-walled, but retain some of the form of the untreated grain.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 90 per cent of the entire number of grains and 93 per cent of the total starch in 15 seconds; in about 95 per cent of the grains and 98 per cent of the total starch in 30 seconds; in about 97 per cent of the grains and over 99 per cent of the total starch in 1 minute. (Chart D 580.)

The hilum becomes very distinct, a bubble is not formed there. The lamellæ also become very distinct and appear so as long as there is any trace remaining of the structure of the untreated grain A narrow, refractive band forms very rapidly about the margin, and the starch constituting this is not gelatinized until all the rest of the grain is gelatinized. Gelatinization begins at the hilum, and immediately afterward at the distal margin. From this point there are two methods of progress. In the first, the starch immediately surrounding the hilum is broken up into granules which persist for some time after the rest of the grain, except that the border before mentioned is gelatinized, then the hilum enlarges rapidly, pushing out the proximal end; then gelatinization proceeds toward the distal end, the starch just inside the refractive border being much the less resistant, it progresses more rapidly in it than in the central portion of the grain, producing a ruffled appearance of the border; in the meantime gelatinization has been progressing less rapidly from the distal end, one lamella after another being gelatinized and thus giving rise to a folded appearance of the capsule at this end. Finally, all the starch is gelatinized except the refractive border which persists for some time, but gradually grows thinner and more nearly transparent, until only a thin capsule is left. In the second method, after the beginning at the hilum and the distal corners, the progress is almost entirely from the proximal end, granules are rarely formed about the hilum, and progress toward the distal end is uniform in all parts. Usually the starch before gelatinization is divided into rows of granules, following the lamellar arrangement by several fissures. A similar refractive border to that noted in the first method is present and this persists after the rest of the grain has been gelatinized, then grows thinner and more transparent as already described. The gelatinized grains are large and usually considerably distorted, especially at the distal end, but they retain considerable of the form of the untreated grain.

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 27 per cent of the entire number of grains and 68 per cent of the total starch in 5 minutes; in about 61 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 80 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 87 per cent of the grains and 97 per cent of the total starch in 45 minutes; in about 93 per cent of the grains and 99 per cent of the total starch in 60 minutes. (Chart D 581.)

The moderately small grains are the most resistant. A small bubble occasionally appears at the hilum, and there is distention of the capsule as a small swelling forms in a number of grains; but in the majority the hilum swells and gelatinization proceeds first from this point towards the distal margin, a refractive marginal band of lamellæ at the proximal end and sides being the most resistant. The lamellæ quickly appear to be more sharply defined and striated, with the exception generally of the narrow refractive band above mentioned, in which the lamellæ may gradually become distinct. Two deep, clean-cut fissures usually proceed from the hilum and are directed obliquely towards the distal corners, forming a sharp boundary between the refractive bilateral border and the mesial portion of the grain; in some grains one median, broad fissure with short branches may proceed through the region of the hilum and then become bifurcated and clean-cut as above mentioned. Occasionally a group of delicate fissures may leave the hilum between the 2 main fissures, or delicate branched fissures may form in the median portion starting from the area nearer the proximal end, which has been gelatinized. The mesial portion is usually broken into moderate to very refractive granules, the latter being in groups, one of which may be located in the area at the hilum, this group being either round or oval and larger than the remainder of the groups. The lamellæ toward the distal margin are often broken down into linear granules, although gelatinization may follow the sharper definition and striation without breaking into granules. The refractive marginal band at the proximal end and sides is very resistant with the exception sometimes of a small area at the proximal end, which frequently may gelatinize without breaking into linear granules.

The gelatinized grains are swollen and distorted, and usually the portion near the distal margin, frequently

throughout the entire grain, is telescoped; a group of refractive granules remain moderately often at the proximal end which is sometimes either concave or raised into a rounded eminence, with depressions on either side. The gelatinized grains do not resemble the form of the untreated grain.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 81 per cent of the entire number of grains and 97 per cent of the total starch in 5 minutes; in about 93 per cent of the grains and 98 per cent of the total starch in 10 minutes; in about 95 per cent of the grains and 99 per cent of the total starch in 15 minutes. (Chart D 582.)

The hilum swells and the lamellæ become sharply defined. Gelatinization more frequently advances quite rapidly through the mesial portion to the distal margin without the formation of definite fissures, a marginal border at the proximal end and sides being the most resistant. In a few grains gelatinization may begin at the proximal end, accompanied by the distention of the capsule, giving rise to the appearance of a small, clear swelling; later it proceeds as described above, the most resistant part being the lateral marginal border, and occasionally also the distal border. The mesial portion is broken down into moderately refractive granules, a group of which are larger, quite refractive, and located around the area of the hilum. This marginal border is very refractive, but gradually the lamellæ of which it is composed become sharply defined and striated, and often break down into linear, very refractive granules previous to gelatinization. The gelatinized grains are much swollen and distorted, more at the distal than proximal end. They do not resemble the untreated grain.

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 89 per cent of the entire number of grains and over 99 per cent of the total starch in 2 minutes; in about 98 per cent of the grains and over 99 per cent of the total starch in 5 minutes. (Chart D 583.)

The reaction is so rapid that the minute steps can not be determined. The gelatinized grains are much swollen and distorted, usually telescoped at the distal region, and a considerable number are telescoped throughout the entire grain, with a concave invagination at the proximal end. When the grains are not distorted at the proximal end, the wall is moderately thick and the remains of 2 or 3 lamellæ can be traced in addition to the capsule. The gelatinized grains do not resemble the form of the untreated grain.

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in 48 per cent of the entire number of grains and 78 per cent of the total starch in 2 minutes; in about 73 per cent of the grains and 95 per cent of the total starch in 5 minutes; in about 98 per cent of the grains and 99 per cent of the total starch in 15 minutes. (Chart D 584.)

A small bubble is occasionally detected at the hilum, which frequently remains small and is very transient, though in a few grains it expands considerably, and its expulsion is followed by an invagination at the proximal end. The lamellæ become very sharply defined and striated, with the exception of a narrow, refractive border at the proximal end and sides. Gelatinization often proceeds without the formation of clearly defined fissures, though 2 oblique fissures may pass from the hilum toward the distal end, while fissures are generally clear-cut, but occasionally branched towards the distal end. The mesial portion of the grain is generally disorganized without the appearance of refractive granules, with the exception of a group of quite large, very refractive granules which often appear in the area near and around the hilum. A few lamellæ at the distal margin are quite resistant, but generally gelatinize without the appearance of granules. A narrow, refractive border at the proximal end and sides, rarely surrounding the entire grains, is the most resistant part of some grains, but it becomes gelatinized without previously breaking down into granules. The grains which are most quickly gelatinized are first attacked at the proximal end, followed quickly by a gelatinization of the refractive border along the sides, an area in the middle of the distal border proving the most resistant.

The gelatinized grains are much swollen and distorted, with a tendency to telescopic folds and to lateral extension at the distal margin; a moderate proportion is thrown into telescopic folds throughout the grain, with either a depression or a concave invagination at the proximal end. The grains are completely gelatinized, no group of granules remaining at the proximal end, as found with some reagents. The gelatinized grains do not resemble the untreated grain.

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 50 per cent of the entire number of grains and 84 per cent of the total starch in 2 minutes; in about 73 per cent of the grains and 95 per cent of the total starch in 5 minutes; in about 95 per cent of the grains and 99 per cent of the total starch in 15 minutes. (Chart D 585.)

A bubble appears at the hilum, which expands to considerable size. The lamellæ immediately become sharply defined and striated, with the exception of a narrow refractive border at the proximal end and sides; the lamellæ in the latter, however, may gradually become defined previous to gelatinization. No well-defined fissures are formed. The starch in both the mesial and marginal regions is disorganized without the appearance of refractive granules. The process more frequently begins at the proximal margin and may extend along the lateral refractive border accompanied by a rufling or fluted appearance of this border; the reaction may then appear at the distal corners and margin before much progress has been made in the mesial region. In the more resistant grains, the bubble at the hilum is more persistent; upon its expulsion the lamellæ through the mesial region become undulating, followed by gelatinization as far as to a few lamellæ at the distal margin, accompanied by lateral distention here, and often gelatinization with distortion at the distal corners and in a narrow border along the margin before a few lamellæ just within the distal margin are gelatinized. In such grains the narrow, refractive border at the proximal end and sides is the most resistant; the lamellæ composing this border may become sharply defined and striated, but are disorganized without the formation of granules.

The gelatinized grains are much swollen and distorted, frequently with telescopic folds throughout the lateral margin, and with either a flattening with a central prominence or a concave area at the proximal end; many grains, however, have a few telescopic folds near the distal margin, with convolutions at the corners, the

region towards the proximal end being either not at all or slightly distorted. The gelatinized grains do not resemble the form of the untreated grains.

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 29 per cent of the entire number of grains and 39 per cent of the total starch in 5 minutes; in about 73 per cent of the grains and 84 per cent of the total starch in 15 minutes; in about 98 per cent of the grains and 99 per cent of the total starch in 30 minutes. (Chart D 586.)

The hilum is moderately distinct, and sometimes a small bubble is formed there, and, just preceding the beginning of gelatinization, there may be seen in some grains 2 or 3 folds or wrinkles in the capsule extending distally from the hilum nearly to the margin. The lamellæ are moderately distinct at first, but later become indistinct. A broad, refractive band is quickly formed about the margin of the grain before gelatinization begins, and proceeds inward from the margin as gelatinization progresses. Gelatinization, in the more quickly-reacting grains, begins at the distal and then at the proximal end, and from these points rapidly encircles the whole margin, and this is followed by a rapid invasion of the ungelatinized starch by cracks, small pieces are broken off and gelatinized, and when the hilum is reached the bubble, if present, swells, then shrinks, and finally disappears, and the starch surrounding the hilum becomes finely granular and then gelatinous. In the more resistant grains, which are in the majority, gelatinization begins, usually, at the distal corners, from which points it extends all along the distal margin, and then to the proximal end, with sudden swelling of the hilum, and with swelling, shrinkage, and disappearance of the bubble if present. From these points, gelatinization (preceded by a somewhat translucent appearance) progresses smoothly, without fissuring or granulation, to the more resistant portion of the grain, of which the margin is the most resistant part and is gelatinized after the central portion is gelatinized. The gelatinized grains are much swollen and distorted and show but little of the form of the untreated grain.

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 36 per cent of the entire number of grains and 72 per cent of the total starch in 5 minutes; in about 72 per cent of the grains and 91 per cent of the total starch in 15 minutes; in about 94 per cent of the grains and 99 per cent of the total starch in 30 minutes. (Chart D 587.)

The reaction with *uranium nitrate* begins in a few grains in 30 seconds. Complete gelatinization occurs in about 28 per cent of the entire number of grains and 65 per cent of the total starch in 5 minutes; in about 60 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 70 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 75 per cent of the grains and 98 per cent of the total starch in 45 minutes; in about the same percentage of both grains and total starch in 60 minutes. (Chart D588.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 63 per cent of the entire number of grains and 84 per cent of the total starch in 2 minutes; in about 90 per cent of the grains and 95 per cent of the total starch in 5 minutes. (Chart D 589.)

The reaction with *cobalt nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 9 per cent of the total starch in 5 minutes; in about 11 per cent of the grains and 32 per cent of the total starch in 15 minutes; in about 28 per cent of the grains and 56 per cent of the total starch in 30 minutes; in about 28 per cent of the grains and 69 per cent of the total starch in 45 minutes; in about 34 per cent of the grains and 72 per cent of total starch in 60 minutes. (Chart D 590.)

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 64 per cent of the entire number of grains and 96 per cent of the total starch in 5 minutes; in about 87 per cent of the grains and 99 per cent of the total starch in 10 minutes; in about 97 per cent of the grains and over 99 per cent of the total starch in 15 minutes. (Chart D 591.)

The reaction with *cupric chloride* begins in a few grains in 30 seconds. Complete gelatinization occurs in about 16 per cent of the grains and 51 per cent of the total starch in 5 minutes; in about 32 per cent of the grains and 76 per cent of the total starch in 15 minutes; in about 49 per cent of the grains and 84 per cent of the total starch in 30 minutes; in about 60 per cent of the grains and 87 per cent of the total starch in 45 minutes; in about 68 per cent of the grains and 90 per cent of the total starch in 60 minutes. (Chart D 592.)

The reaction with *barium chloride* begins in a few grains in 30 seconds. Complete gelatinization occurs in rare grains, less than 0.5 per cent of the entire number of grains, and 1 per cent of the total starch in 5 minutes; in about 0.5 per cent of the grains and 2 per cent of the total starch in 15 minutes; in about 2 per cent of the grains and 3 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes, respectively. (Chart D 593.)

The reaction with *mercuric chloride* begins immediately. Complete gelatinization occurs in about 11 per cent of the grains and 55 per cent of the total starch in 5 minutes; in about 28 per cent of the grains and 74 per cent of the total starch in 15 minutes; in about 32 per cent of the grains and 83 per cent of the total starch in 30 minutes; in about 52 per cent of the grains and 90 per cent of the total starch in 45 minutes; in about the same percentage of both the grains and total starch in 60 minutes. (Chart D 594.)

Phaius wallichii (Pollen Parent).

(Plate 23, fig. 139; Charts D 574 to D 594.)

Histologic Properties.

In *form* most of the grains are simple and isolated with the exception of a few which appear in aggregates of usually 2, rarely 3, components. Compound and semi-compound grains of usually 2, rarely 3, components are sometimes observed. The proportion of aggregates and compound grains is greater than in *P. grandifolius.* Well-defined pressure facets are not present, as was also noted in *P. grandifolius.* The grains are frequently irregular, much more often than in *P. grandifolius,* the irregularities being of the same character, but given forms of irregularity vary in frequency as follows: the nipple-like excrescence or protuberance is less frequent; a moderately large, rounded protuberance near the proxi-

mal end, not noted in *P. grandifolius;* the long blunt extension at the end is much more frequent than in *P. grandifolius;* abrupt shifting of the longitudinal axis is much more common; a pointed spicule-like and a flared refractive excrescence or addition to the distal end are less often observed; and secondary lamellæ are more numerous and much more frequently placed at a right angle to the proximal end and arranged bilaterally at the distal end, than in *P. grandifolius.* The conspicuous forms are ovoid, often elongated with broadened and squared distal end; pyriform with broadened distal end, and also frequently with elongated tapering proximal end; bottle- or ten-pin-shape and club-shape, the latter sometimes curved. Additional forms are triangular with rounded angles; pure ovoid; quadrangular with rounded angles and curved sides; boot-, pipe-, hatchet-shape, and grains of indefinite shape. Both the conspicuous and the additional forms are more varied in shape and of a more slender type than in *P. grandifolius.* The grains are flattened, some much more than others, and when viewed on edge are of about the same form as in *P. grandifolius.*

The *hilum* is distinct in more grains and slightly more refractive than in *P. grandifolius.* It is either a lenticular or round, usually non-refractive to slightly refractive, occasionally quite refractive, spot as in *P. grandifolius.* A small, longitudinal, slit-like cavity at the hilum is rare, though more frequent than in *P. grandifolius.* The hilum is rarely fissured as in *P. grandifolius;* but the oblique fissures which extend from the hilum and are almost immediately deflected so as to be about parallel to each other are somewhat more frequent than in *P. grandifolius.* The range of eccentricity of the hilum varies from 0.2 to 0.03; commonly 0.08 to 0.05 of the longitudinal axis. There is a greater variation, with the mean less eccentric, than in *P. grandifolius.*

The *lamellæ* in their general characteristics and arrangement are about the same as in *P. grandifolius.* The refractive proximal and lateral band is more numerous and varies more in width; a group of undulating lamellæ, either about the middle or nearer the distal end of the grain, is rarely observed, less often than in *P. grandifolius.* Secondary sets of lamellæ are more numerous, often larger and more variably located, much more frequently being either bilateral and located at either side of a pointed distal end, or unilateral and placed at right angles to the proximal end or even inclosing the primary set than in *P. grandifolius.* The number on much-elongated grains may reach 130, but is about 100 on the usual large sized grains, about the same as in *P. grandifolius.*

The *size* of the grains varies from the smaller which are 7 by 5μ, to the larger which are 116 by 50μ, in length and breadth. The common size is about 78 by 36μ in length and breadth. The larger grains are shorter and broader than in *P. grandifolius.*

Polariscopic Properties.

The *figure* is usually very eccentric, although a larger proportion is less eccentric than in *P. grandifolius,* hence a greater variation with the mean less eccentric. The lines are fine and intersect obliquely as in *P. grandifolius,* but they are much more often bent, with more distortion and also more frequently bisected, than in *P. grandifolius.* A larger proportion of double figures is observed.

The *degree of polarization* is moderate to very high, with the majority high (value 80). There is greater variation in the different grains, with the mean lower than in *P. grandifolius.* A great variation is also often found in the same aspect of a given grain, more often than in *P. grandifolius.*

With *selenite* the quadrants are usually well defined, unequal in size, and generally quite irregular in shape, much more of the latter than in *P. grandifolius.* The colors show the same kinds of impurity as in *P. grandifolius,* more of the orange and purplish tint but less of the greenish tinge and iridescence; taking the mean of both ends of the scale, the purity is about as in *P. grandifolius.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains immediately color a light to moderate blue-violet which is slightly less bluish in tint and lighter than in *P. grandifolius* (value 40). The color deepens rapidly with greater variation among the different grains, the mean not quite so bluish nor so deep as in *P. grandifolius.* With 0.125 per cent Lugol's solution the grains immediately color a light blue-violet which is slightly lighter and less bluish than in *P. grandifolius;* the color deepens rapidly, but there is much more variation in depth among the different grains, the mean being slightly lighter and less bluish than in *P. grandifolius.* After heating in water until the grains are gelatinized and then adding 2 per cent Lugol's solution the *grains* become a moderately deep to deep blue, many with reddish tint; there is greater variation among the different grains, with the mean somewhat lighter than in *P. grandifolius;* the *solution* is about the same depth. If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues,* of which but few remain, though more than in *P. grandifolius,* become a moderately deep blue with reddish tint, deeper and a little less reddish than in *P. grandifolius;* most of the *capsules* become either a deep old-rose or deep reddish-heliotrope, with a few wine-red; the color is more varied, the mean a little less reddish than in *P. grandifolius.*

Aniline Reactions.

With *gentian violet* the grains immediately color very lightly, and in 30 minutes they are light to moderately deep in color, fewer of the latter than in *P. grandifolius* (value 50); the depth is more varied, with the mean lighter than in *P. grandifolius.* The variation in depth of the different parts of the grain is about the same as in *P. grandifolius,* with the exception that when the secondary set of lamellæ is as large or larger than the main body of the grain, which occurs frequently in this species, there is generally no difference in depth between the secondary set and the main body of the grain.

With *safranin* the grains immediately color very lightly and in 30 minutes they are light to moderately deep, a little deeper than with gentian violet (value 55), the grains are more varied in depth, with the mean somewhat lighter than in *P. grandifolius.* The variation in depth of tint is the same as noted with gentian violet.

Temperature Reactions.

The majority of the grains are gelatinized at 64° to 65° C., and of all but rare resistant grains at 67°

to 68° C., mean 67.5° C. The outermost marginal lamellæ at the proximal end and sides nearby are less resistant than in *P. grandifolius.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in a few grains immediately. Complete gelatinization occurs in about 14 per cent of the entire number of grains and 27 per cent of the total starch in 5 minutes; in about 48 per cent of the grains and 48 per cent of the total starch in 15 minutes; in about 55 per cent of the grains and 61 per cent of the total starch in 30 minutes; in about 62 per cent of the grains and 67 per cent of the total starch in 45 minutes; little if any further change in 60 minutes. (Chart D 574.)

The hilum becomes more distinct than in *P. grandifolius* and a bubble is formed there, more frequently than in *P. grandifolius;* and two lines, and also more frequently two folds or wrinkles, in the capsule are seen extending from the hilum to the distal margin, as in *P. grandifolius.* The lamellæ become more distinct than in *P. grandifolius,* and a refractive band, broad at the proximal end, and in which the lamellæ are more distinct, is quickly formed about the margins of the grains. Gelatinization (unlike in the grains of *P. grandifolius*) begins at the proximal end in most of the grains, accompanied by rapid swelling of the hilum, and then at the distal end; in some others at the sharp corners at the distal end and then at the proximal end; and in a few it proceeds entirely from the distal end, the proximal end being the most resistant. The progress of gelatinization is essentially the same as in *P. grandifolius,* and the cup-shaped hollows noted in the more resistant grains of that starch are here not quite so numerous or so deep. The gelatinized grains are very large and more distorted than in *P. grandifolius* and retain less of the form of the untreated grain.

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 10 per cent of the entire number of grains and 67 per cent of the total starch in 5 minutes; in about 61 per cent of the grains and 97 per cent of the total starch in 15 minutes; in over 99 per cent of both the grains and total starch in 30 minutes. (Chart D 575.)

The hilum is more distinct than in *P. grandifolius,* and no bubble is observed to form there. The lamellæ are at first more distinct than in *P. grandifolius,* but later are obscured and do not reappear as in *P. grandifolius.* A refractive band (broader at the proximal end and not visible at the distal end) is observed to form about the margins of some of the grains. Gelatinization, as in *P. grandifolius,* begins at the hilum. Two lines of fissures extend distally from the hilum just inside the line made by the refractive band noted above, and these branch out extensively in all directions through the grain, dividing the starch into many coarse granules. The starch immediately proximal to the hilum, in the meantime, is rapidly gelatinized, forming a broad canal from the hilum to the thin capsule. Then as the granular starch becomes gelatinous, the capsule at the proximal end or at one of the distal corners is dissolved, and the gelatinous starch flows out and is dissolved. The dissolution of the capsule is much later in the process of gelatinization than in *P. grandifolius* and the grains collapse and are dissolved more rapidly after it has taken place than in those grains. Shreds of the capsule remain and dissolve more slowly than the rest of the grain as in *P. grandifolius.*

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 16 per cent of the entire number of grains and 63 per cent of the total starch in 5 minutes; in about 43 per cent of the grains and 80 per cent of the total starch in 15 minutes; in about 57 per cent of the grains and 85 per cent of the total starch in 30 minutes; in about 68 per cent of the grains and 91 per cent of the total starch in 45 minutes; in about 71 per cent of the grains and 94 per cent of the total starch in 60 minutes. (Chart D 576.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 55 per cent of the entire number of grains and 90 per cent of the total starch in 1 minute; in about 93 per cent of the grains and 99 per cent of the total starch in 5 minutes; in about 96 per cent of the grains and over 99 per cent of the total starch in 10 minutes; in over 99 per cent of both the grains and total starch in 15 minutes. (Chart D 577.)

The hilum swells and a bubble frequently appears which enlarges even less and is as a rule more transient than in *P. grandifolius.* Gelatinization with extension is more marked at the proximal end, and the central portion of the distal end is more resistant than in *P. grandifolius.* The most resistant grains are those similar in shape and with the narrow refractive resistant border at proximal end and sides, as in *P. grandifolius.* The gelatinized grains are swollen and more distorted, especially at the proximal end, than in *P. grandifolius.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 88 per cent of the entire number of grains and 96 per cent of the total starch in 1 minute; in over 99 per cent of both the grains and total starch in 2 minutes; complete gelatinization (100 per cent) in 2 minutes and 30 seconds. (Chart D 578.)

The reaction with *hydrochloric acid* occurs immediately. Complete gelatinization occurs in about 95 per cent of the entire number of grains and over 99 per cent of the total starch in 1 minute; all but parts of rare grains, over 99 per cent of both the entire number of grains and total starch in 1 minute and 30 seconds. (Chart D 579.)

The hilum, as in *P. grandifolius,* becomes very distinct, but no bubble is formed there. The lamellæ are more distinct than in *P. grandifolius.* A very refractive band is formed, as in *P. grandifolius,* about the margin of the grain before gelatinization begins, and this is broader at the proximal than at the distal end. Gelatinization begins at the hilum, as in *P. grandifolius,* but no granules are formed immediately about the hilum as in those grains. Two lines of fissures extend distally from the hilum and these by many irregular branches divide the starch of the grain into coarse granules which do not show much of a lamellar arrangement and in this respect differ from those found in the grains of *P. grandifolius.* Otherwise the process is the same as noted under *P. grandifolius.* The gelatinized grains are large, very nearly transparent, very thin-walled, and more distorted at the distal end than in *P. grandifolius.*

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 95 per cent of the entire number of grains and 98 per cent of the total starch in 15 seconds; complete gelatinization of all grains occurs in 30 seconds. (Chart D 580.)

The hilum becomes more distinct than in *P. grandifolius,* and the lamellæ also appear more distinct, but do not remain visible during the greater part of the reaction as in *P. grandifolius.* A refractive band about the margin is not usually to be distinguished owing to the rapidity of the reaction. Gelatinization begins at the proximal end and this is occasionally but not usually followed by gelatinization at the corners of the distal margin. The hilum enlarges very greatly and very rapidly and pushes out the proximal end of the grain. Two widely branching fissures run rapidly from the hilum, just inside the margin, to the distal end and these divide the starch between the hilum and the distal end into many rather coarse, irregularly placed granules, and a gelatinization and swelling of the grain proceed distalwards from the proximal end, this part of the grain opening out fan-wise with considerable infolding and invagination of the capsule at different points. In many grains a granular appearance persists here for a considerable time after gelatinization is complete in the rest of the grain. The gelatinized grains are larger and thinner-walled than in *P. grandifolius,* but somewhat less distorted than in that starch.

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 58 per cent of the entire number of grains and 90 per cent of the total starch in 5 minutes; in about 83 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 92 per cent of the grains and 98 per cent of the total starch in 30 minutes; in about 95 per cent of the grains and 99 per cent of the total starch in 45 minutes; in about 99 per cent of the grains and over 99 per cent of the total starch in 60 minutes. (Chart D 581.)

A bubble appears less frequently at the hilum than in *P. grandifolius* and the beginning of gelatinization with distention of the capsule at the proximal end was not observed. The process follows the course more frequently found in *P. grandifolius,* but there it is accompanied with more general distortion and elongation of the proximal end of many grains. The lamellæ are not so sharply defined and their definition is much more quickly lost. The 2 fissures which leave the hilum may be at first clean-cut, but they very soon become much branched and plume-like; in the narrower grains a large, single, plume-like fissure may be found; the fissures are much more commonly diffusely branched than in *P. grandifolius.* The mesial region is usually disorganized with the appearance of less refractive granules, and the lamellæ near the distal margin, as well as in the marginal band at the proximal end and sides, are less frequently broken down into linear granules than in *P. grandifolius.* This marginal band at the proximal end and sides is usually not so broad nor so resistant as in *P. grandifolius;* even in grains resembling this species in form and with a moderately broad border, this band usually becomes undulating and gelatinized without breaking into granules.

The gelatinized grains are swollen and distorted, the latter more throughout the entire margin of the grain; the majority of grains are elongated and often undulating at the proximal end, and rarely depressed as found moderately often in *P. grandifolius.* A group of refractive granules appears at the hilum with less frequency, since they are much less resistant than in *P. grandifolius.* The gelatinized grains do not resemble the form of the untreated grain as in *P. grandifolius.*

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 93 per cent of the entire number of grains and over 99 per cent of the total starch in 5 minutes; in about 98 per cent of the grains and over 99 per cent of the total starch in 10 minutes; in about 99 per cent of the grains and over 99 per cent of the total starch in 15 minutes. (Chart D 582.)

The hilum swells as noted in *P. grandifolius,* but the lamellæ do not become nearly so sharply defined. Two plume-like fissures usually proceed obliquely from the hilum to the distal end, and sometimes an additional median, branched fissure or a group of median fissures appear in broader grains; definite fissures with the exception of those between lateral border and mesial portion are usually absent in *P. grandifolius.* The mesial portion is generally broken down into much less refractive granules, and the group of granules around the hilum is much less frequent than in *P. grandifolius.* The border at the middle of the distal margin is frequently the most resistant part, instead of at the proximal end, as noted for *P. grandifolius,* but the distal corners are much less resistant and are gelatinized with more distortion than in *P. grandifolius.* The gelatinized grains are more distorted, especially at the proximal end than in *P. grandifolius;* they, as in that species, do not resemble the shape of the untreated grain.

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 93 per cent of the grains and over 99 per cent of the total starch in 2 minutes; in about 99 per cent of both the grains and total starch in 5 minutes. (Chart D 583.)

The reaction is so rapid that the minute steps can not be satisfactorily determined as in *P. grandifolius.* The gelatinized grains are much swollen and distorted; less frequently evenly telescoped at the distal margin than in *P. grandifolius,* the distal corners at least being thrown into convolutions. The entire grain is rarely telescoped, with concave invagination at the proximal end, as found moderately often in *P. grandifolius.* The wall of the gelatinized grain, especially at the proximal end, when not distorted at this point is thinner than in *P. grandifolius.* The gelatinized grains do not resemble the form of the untreated grain as in *P. grandifolius.*

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 70 per cent of the entire number of grains and 92 per cent of the total starch in 2 minutes; in about 85 per cent of the grains and 97 per cent of the total starch in 5 minutes; in about 98 per cent of the grains and over 99 per cent of the total starch in 15 minutes. (Chart D 584.)

A bubble is sometimes detected, more frequently than in *P. grandifolius;* it reacts in the same manner as noted in that species. The lamellæ become more sharply defined, but the definition is not so sharp as in *P. grandifolius.* Two fissures which branch profusely, especially in the region of the distal corners, are usually formed,

and are much more frequently present, as well as more branched, than in *P. grandifolius.* The different regions are disorganized as in *P. grandifolius,* but the quite refractive areas are much less frequently observed. The reaction begins at the proximal end in the majority of grains, but instead of advancing along the narrow refractive border of the sides, as so often observed in *P. grandifolius,* the disorganization occurs also in the mesial portion of the proximal end. The distal corners are more frequently gelatinized with distortion than in *P. grandifolius.*

The gelatinized grains are much swollen and distorted, more of the latter than in *P. grandifolius.* The distal margin is more frequently thrown into irregular folds, and the proximal end more frequently elongated and irregularly distorted than in *P. grandifolius.* The gelatinized grains do not resemble the untreated grains as in *P. grandifolius.*

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 67 per cent of the entire number of grains and 92 per cent of the total starch in 2 minutes; in about 82 per cent of the grains and 96 per cent of the total starch in 5 minutes; in about 96 per cent of the grains and 99 per cent of the total starch in 15 minutes. (Chart D 585.)

A bubble appears at the hilum which expands to considerable size as in *P. grandifolius.* The lamellæ become sharply defined and striated as in *P. grandifolius.* Usually 2 fissures appear which are not deep, but are much branched, especially towards the distal corners, and are much more frequently present than in *P. grandifolius.* The starch in both the mesial and marginal regions is disorganized without the formation of refractive granules as in *P. grandifolius.* The process more frequently begins as in *P. grandifolius,* with the exception that all the starch across the proximal end gelatinizes, accompanied by irregular distortion at this end instead of a ruffling of the narrow lateral border, the latter being usually noted in *P. grandifolius.* The distal corners and margins are quickly gelatinized, accompanied by much distortion, more distortion than in *P. grandifolius.* In a few grains the narrow, refractive, proximal and lateral borders are the most resistant—fewer grains of this nature than in *P. grandifolius,* but they gelatinize in a similar manner. The reaction is so rapid that no further minute differences between the species can be determined. The gelatinized grains are much swollen and irregularly distorted, often with the proximal end much extended and irregularly twisted, with more distortion and more extension at the proximal end than in *P. grandifolius.*

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 45 per cent of the grains and 54 per cent of the total starch in 5 minutes; in about 94 per cent of the grains and 97 per cent of the total starch in 15 minutes; in over 99 per cent of both the entire number of grains and total starch in 30 minutes. (Chart D 586.)

The hilum becomes more distinct than in *P. grandifolius,* and a small bubble is more often formed there; the folds or wrinkles in the capsule extending from the hilum to the distal margin noted in *P. grandifolius* are also present here. The lamellæ are more distinct at first than in *P. grandifolius* and later become indistinct as in that starch. A refractive band (less distinct than in *P. grandifolius*) is formed quickly about the margin of the grain, and it recedes as gelatinization progresses. Gelatinization unlike that of the grains of *P. grandifolius* begins usually at the proximal end, and this is followed by gelatinization of the corners of the distal margin, and then of the whole distal end. Gelatinization progresses smoothly from its initial points, and more rapidly from the proximal than from the distal end, but the marginal starch, differing from that in the grains of *P. grandifolius,* is less resistant than the central portion, the most resistant part of which is usually found midway between the hilum and the distal margin, or just at the distal end, in any case nearer to the distal end than in *P. grandifolius.* The gelatinized grains are very large and much distorted and do not retain as much of the form of the untreated grain as do those of *P. grandifolius.*

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 61 per cent of the entire number of grains and 83 per cent of the total starch in 5 minutes; in about 94 per cent of the grains and over 99 per cent of the total starch in 15 minutes; in about 99 per cent of the grains and over 99 per cent of the total starch in 30 minutes. (Chart D 587.)

The reaction with *uranium nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 63 per cent of the entire number of grains and 90 per cent of the total starch in 5 minutes; in about 78 per cent of the grains and 98 per cent of the total starch in 15 minutes; in about 93 per cent of the grains and over 99 per cent of the total starch in 30 minutes; little if any further change occurs in 45 and 60 minutes. (Chart D 588.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 83 per cent of the entire number of grains and 91 per cent of the total starch in 2 minutes; in about 99 per cent of the grains and over 99 per cent of the total starch in 5 minutes; in 100 per cent of both the grains and total starch in 9 minutes. (Chart D 589.)

The reaction with *cobalt nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in about 7 per cent of the entire number of grains and 48 per cent of the total starch in 5 minutes; in about 31 per cent of the grains and 78 per cent of the total starch in 15 minutes; in about 45 per cent of the grains and 87 per cent of the total starch in 30 minutes; in about 55 per cent of the grains and 90 per cent of the total starch in 45 minutes; in about 63 per cent of the grains and 96 per cent of the total starch in 60 minutes. (Chart D 590.)

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 86 per cent of the entire number of grains and over 99 per cent of the total starch in 5 minutes; in over 99 per cent of both the grains and total starch in 10 minutes. (Chart D 591.)

The reaction with *cupric chloride* begins in a few grains immediately. Complete gelatinization occurs in about 39 per cent of the entire number of grains and 82 per cent of the total starch in 5 minutes; in about 63 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 81 per cent of the grains and 97 per cent of the total starch in 30 minutes; in about 89 per cent of the grains and 98 per cent of the total

starch in 45 minutes; in about 91 per cent of the grains and 99 per cent of the total starch in 60 minutes. (Chart D 592.)

The reaction with *barium chloride* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 8 per cent of the total starch in 15 minutes; in about 7 per cent of the grains and 11 per cent of the total starch in 30 minutes; in about 10 per cent of the grains and 19 per cent of the total starch in 45 minutes; in about 16 per cent of the grains and 25 per cent of the total starch in 60 minutes. (Chart D 593.)

The reaction with *mercuric chloride* begins immediately. Complete gelatinization occurs in about 32 per cent of the entire number of grains and 81 per cent of the total starch in 5 minutes; in about 59 per cent of the grains and 91 per cent of the total starch in 15 minutes; in about 74 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 81 per cent of the grains and 97 per cent of the total starch in 45 minutes; in about 86 per cent of the grains and 99 per cent of the total starch in 60 minutes. (Chart D 594.)

Phaius hybridus (Hybrid).

(Plate 27, fig. 138; Charts D 574 to D 594.)

Histologic Properties.

In *form* most of the grains are simple and isolated, with the exception of a few which appear in aggregates of usually 2, rarely 3, components. Compound and semi-compound grains usually of 2, rarely 3, components are sometimes observed. The proportion of aggregates and compound grains is larger than in either parent. Well-defined pressure facets are not present. Most of the grains are regular, but the irregularities noted in both parents are observed, though occurring with less frequency than in either parent. The conspicuous forms are ovoid, often elongated, with broadened and squared distal margin; pyriform with broadened distal end; pure ovoid; triangular with rounded angles; pyriform with elongated, tapering, proximal end; and club-shaped. In addition there are curved-club-, bottle- or ten-pin-, oyster-shell-, spindle-, boot-, urn- and knob-shaped, also grains of indefinite shape. There are somewhat more of the slender type than in *P. grandifolius*, but they are much less numerous than in *P. wallichii*. The grains are flattened, some much more than others, and when viewed on edge are narrow ellipsoidal with distal end squared, as in both parents. In form these grains are closer to *P. grandifolius* than to *P. wallichii*.

The *hilum* is of similar shape, but is more refractive and more frequently demonstrable than in both parents. A longitudinal, slit-like cavity is of about the same frequency as in *P. grandifolius*, but less frequent than in *P. wallichii*. While the hilum is usually unfissured, yet fissures of slightly more varied character occur, and with a little more frequency than in both parents. These clefts in addition to arrangement found in both parents are sometimes so placed as to form a soaring-bird figure. The range of eccentricity is from about 0.16 to 0.024, commonly about 0.08 to 0.05, of the longitudinal axis. In the character of the hilum these grains are slightly closer to those of *P. wallichii*.

The *lamellæ* are usually demonstrable throughout the entire grain, but are often less distinct and finer near the hilum as noted for both parents. The primary set have about the same character and arrangement as in both parents, with the exception that they are relatively coarser in a larger proportion of grains. The refractive border at the proximal and lateral margins is more frequently present, and is of about the same width as in *P. grandifolius*, but it is somewhat broader, as a rule, and about as frequent as in *P. wallichii*. Secondary sets of lamellæ are somewhat more frequent and often larger, but commonly located as in *P. grandifolius;* but less numerous, less often large, and less varied in location, than in *P. wallichii*. The number may reach 153 on very large elongated grains, and about 100 on the common large-sized grains. In character and arrangement of lamellæ these grains are slightly closer to *P. grandifolius*, but the numbers in both parents and hybrid are practically the same.

The *size* varies from the smaller which are 6 by 4μ, to the larger which are 150 by 48μ, in length and breadth. The common size is about 74 by 38μ in length and breadth. In size the grains are closer to *P. grandifolius*.

Polariscopic Properties.

The *figure* is usually very eccentric, although there are more of the less eccentric than in *P. grandifolius*, but more of the very eccentric than in *P. wallichii;* the mean is slightly less than *P. grandifolius*, and somewhat more than *P. wallichii*. The lines are fine and intersect obliquely, as in both parents; they are somewhat more often bent and bisected than in *P. grandifolius*, but much less than in *P. wallichii*. The proportion of double figures is somewhat larger than in both parents.

The *degree of polarization* is high to very high (value 87), more of the latter than in either parent, and hence the mean is higher than in them. There is about the same variation in the different grains as in *P. grandifolius*, but much less than in *P. wallichii*. A variation is frequently present on the same aspect of a given grain; found in a slightly larger proportion of grains than in *P. grandifolius*, but less than in *P. wallichii*.

With *selenite* the quadrants are well defined and unequal in size as in both parents; they are slightly more irregular in shape than in *P. grandifolius*, but not nearly so irregular as in *P. wallichii*. The colors show impurity from both ends of the scale, considerably more with the greenish tinge and irridescence than in both parents, making the mean of impurity slightly higher than in either parent.

In the *degree of polarization*, in the character of the figure, and in the appearance with selenite, these grains are closer to *P. grandifolius*.

Iodine Reactions.

With 0.25 per cent Lugol's solution, the grains color a moderate blue-violet immediately (value 43), not so deep and less bluish than in *P. grandifolius;* near the tint, but deeper than in *P. wallichii;* the color deepens rapidly, becoming more bluish. There is greater variation in depth among the grains, with the mean slightly lighter than in *P. grandifolius;* not so much variation, with the mean deeper than in *P. wallichii*. With 0.125 per cent Lugol's solution the grains immediately color a light blue-violet, not so deep as in *P. grandifolius*,

and deeper than in *P. wallichii.* After heating in water until the grains are gelatinized and then adding 2 per cent Lugol's solution, the *grains* become moderate to deep blue, some with reddish tint, the depth is somewhat more varied, with the mean a little lighter and not so many of reddish tint as in both parents. If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution, the rare *grain-residues* (less than in both parents) become light to moderate blue, with a somewhat reddish tint, about the same depth but less reddish than in *P. grandifolius,* and little lighter but as reddish as in *P. wallichii;* most of the *capsules* color a deep reddish-heliotrope, with a few wine-red, a little deeper and less reddish than in *P. grandifolius,* less varied and the mean deeper and slightly more reddish than in *P. wallichii.* In the reactions with iodine *P. hybridus* is closer to *P. wallichii* than to *P. grandifolius.*

Aniline Reactions.

With *gentian violet* the grains immediately color very lightly, and in 30 minutes they are moderate to deep (value 60), slightly deeper than in *P. grandifolius,* but considerably deeper than in *P. wallichii.* A variation in depth of color occurs as in both parents, the hilum being more often deeply colored than in them. The greater depth of color appears to be related to the lamellæ, which in the hybrid are coarser in most of the grains than in the parents.

With *safranin* the grains immediately color lightly, and in 30 minutes they are moderately deep to deep (value 65), deeper than in both parents. The grains stain more deeply with this reagent than with gentian violet as in both parents. The variations in depth of the different parts of the grain are the same as for gentian violet as in both parents. In the reactions with aniline stains *P. hybridus* is closer to *P. grandifolius* than to *P. wallichii.*

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is at 64° to 66° C., and of all but rare resistant grains at 66 to 68° C., mean 67° C. The proximal end and sides nearby are not so resistant as in *P. grandifolius,* and about as in *P. wallichii.* The temperature of gelatinization of *P. hybridus* is less than that of either parent, and is closer to that of *P. wallichii.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins in a few grains immediately. Complete gelatinization occurs in about 23 per cent of the entire number of grains and 21 per cent of the total starch in 5 minutes; in about 36 per cent of the grains and 44 per cent of the total starch in 15 minutes; in about 52 per cent of the grains and 56 per cent of the total starch in 30 minutes; in about 56 per cent of the grains and 66 per cent of the total starch in 45 minutes; in about 60 per cent of the grains and 70 per cent of the total starch in 60 minutes. (Chart D 574.)

The hilum becomes as distinct as in *P. grandifolius,* rarely a bubble is formed there, and there is the same formation of lines or fissures and wrinkles in the capsule as noted in the parents. The lamellæ become as distinct as in *P. grandifolius,* and a refractive band about the margin is quickly formed as in both parents. Gelatinization usually begins at the distal end, then at the proximal end as in *P. grandifolius,* though there are some grains in which it begins at the proximal end as in *P. wallichii.* The progress of gelatinization is the same as noted under *P. grandifolius.* The gelatinized grains are very large and are distorted as in *P. grandifolius,* and do not retain much of the form of the untreated grain. In this reaction *P. hybridus* qualitatively shows a closer relationship to *P. grandifolius* than to *P. wallichii.*

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 44 per cent of the total starch in 5 minutes; in about 34 per cent of the grains and 87 per cent of the total starch in 15 minutes; in about 98 per cent of the grains and over 99 per cent of the total starch in 30 minutes. (Chart D 575.)

The hilum, as in *P. grandifolius,* is distinct, as are also the lamellæ, and the lamellæ are obscured and later appear as rows of granules. The refractive band noted in the parents is also seen here. Gelatinization, as in the parents, begins at the hilum. The method of gelatinization in the majority of grains is that noted under *P. grandifolius,* although in some it is the same as in *P. wallichii.* In this reaction *P. hybridus* shows a closer relationship to *P. grandifolius* than to *P. wallichii.*

The reaction with *pyrogallic acid* begins in a few grains immediately. Complete gelatinization only occurs in a few grains, less than 0.5 per cent of the entire number of grains, and 8 per cent of the total starch, in 5 minutes; in about 12 per cent of the grains and 62 per cent of the total starch in 15 minutes; in about 23 per cent of the grains and 70 per cent of the total starch in 30 minutes; in about 36 per cent of the grains and 77 per cent of the total starch in 45 minutes; in about 44 per cent of the grains and 84 per cent of the total starch in 60 minutes. (Chart D 576.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 44 per cent of the entire number of grains and 78 per cent of the total starch in 1 minute; in about 87 per cent of the grains and 99 per cent of the total starch in 5 minutes; in about 94 per cent of the grains and 99 per cent of the total starch in 10 minutes; in about 99 per cent of the grains and over 99 per cent of the total starch in 15 minutes. (Chart D 577.)

The hilum swells, and a bubble, which enlarges often to considerable size and may be quite persistent, is more frequent than in both parents. Gelatinization begins and proceeds as in both parents. The minute steps and the most resistant starch more closely adhere to that noted for *P. grandifolius* than *P. wallichii.* The gelatinized grains are swollen and distorted, about as in *P. grandifolius;* less than in *P. wallichii.* These reactions are closer to *P. grandifolius* than to the other parent.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 75 per cent of the grains and 92 per cent of the total starch in 1 minute; in about 98 per cent of the grains and 99 per cent of the total starch in 2 minutes; complete gelatinization of all the grains in 3 minutes. (Chart D 578.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 92 per

cent of the entire number of grains and 99 per cent of the total starch in 1 minute; all grains are completely gelatinized with the exception of parts of rare grains, over 99 per cent of both the entire number of grains and total starch in 1 minute and 30 seconds. (Chart D 579.)

The hilum, as in *P. grandifolius,* becomes very distinct and a bubble is not so frequently formed there. The lamellæ are even less distinct than in *P. grandifolius,* and very much less distinct than in *P. wallichii.* A broad, refractive band is found as in the parents. Gelatinization begins at the proximal end and progresses as in *P. grandifolius,* except that not all the grains have granules formed and persisting at the proximal end, and when such granules are present they are not so coarse as in *P. grandifolius.* The gelatinized grains are large, nearly transparent, and very thin-walled, but as in *P. grandifolius* they retain some of the form of the untreated grain. In this reaction *P. hybridus* shows a closer relationship to *P. grandifolius* than to *P. wallichii.*

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 91 per cent of the entire number of grains and 94 per cent of the total starch in 15 seconds; in about 99 per cent of the grains and over 99 per cent of the total starch in 30 seconds. (Chart D 580.)

The hilum becomes as distinct as in *P. grandifolius,* and also the lamellæ, which persist nearly to the end of the reaction as in *P. grandifolius.* A refractive band about the margin can be noted, and the starch constituting this is not gelatinized until after that of the rest of the grain as in *P. grandifolius.* Gelatinization begins at the hilum, and only occasionally at the distal end as in *P. wallichii.* From this point the progress is the same in most of the grains as in *P. grandifolius,* and in a few as in *P. wallichii.* The gelatinized grains, as in *P. grandifolius,* are large and usually considerably distorted, especially at the distal end, but they retain considerable of the forms of the untreated grain. In this reaction *P. hybridus* is qualitatively closer to *P. grandifolius* than to *P. wallichii.*

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 39 per cent of the entire number of grains and 82 per cent of the total starch in 5 minutes; in about 82 per cent of the grains and 92 per cent of the total starch in 15 minutes; in about 93 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 95 per cent of the grains and 98 per cent of the total starch in 45 minutes; in about 97 per cent of the grains and 99 per cent of the total starch in 60 minutes. (Chart D 581.)

A bubble appears about as frequently as in *P. grandifolius,* and more frequently than in *P. wallichii,* and it enlarges to greater size in more grains than in both parents. Gelatinization rarely begins at the proximal end, accompanied by a small distention of the capsule at that part, this occurring less frequently than in *P. grandifolius.* This method was not observed in *P. wallichii.* The lamellæ become more sharply defined and striated as in both parents, but the definition is more quickly lost than in *P. grandifolius,* but hardly so rapidly as in *P. wallichii.* The fissures more frequently are the same as in *P. grandifolius,* though branching towards the distal margin is more common than in this species; but not nearly so frequently branched as in *P. wallichii.* A group of delicate fissures forms between the 2 main oblique fissures much more frequently than in *P. grandifolius,* followed by the more rapid gelatinization of the mesial portion, often with the appearance of only slightly refractive granules in the area around the hilum. The granules of the mesial region are less refractive than in *P. grandifolius,* and the mean is somewhat more than in *P. wallichii.* The marginal border at the proximal end and sides is more frequently moderately broad than in either parent, and less often breaks into linearly arranged granules than in *P. grandifolius,* and about as in *P. wallichii.* The lamellæ toward the distal margin are less frequently disorganized into linear granules previous to gelatinization than in *P. grandifolius,* and about as in *P. wallichii.*

The gelatinized grain is swollen and distorted, more closely resembling that of *P. grandifolius,* though less frequently telescoped throughout the depressed proximal end; and less distorted throughout the margin than in *P. wallichii.* The border at the proximal end and sides is less resistant, as well as the group of quite refractive granules around the hilum, than in *P. grandifolius,* but the granules more frequently remain than in *P. wallichii.* The gelatinized grains, as in the parents, do not resemble the form of the untreated grain. These reactions are closer to those of *P. grandifolius* than to those of the other parent.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 89 per cent of the entire number of grains and 97 per cent of the total starch in 5 minutes; in about 96 per cent of the grains and 99 per cent of the total starch in 15 minutes; in about 97 per cent of the grains and over 99 per cent of the total starch in 30 minutes. (Chart D 582.)

The reaction begins and proceeds as in both parents, the minute steps more closely following those of *P. grandifolius.* The lamellæ are not quite so sharply defined as in *P. grandifolius,* but decidedly more than in *P. wallichii.* Fissures do not generally form, as in *P. grandifolius,* but not in *P. wallichii.* A broader refractive band at the proximal end and sides bounds the mesial gelatinized region more often than in either parent. The mesial portion is broken down into moderately refractive granules, often with a more refractive group in the area around the hilum; the hilum is not quite so refractive as in *P. grandifolius,* but more refractive and the group is more frequently present than in *P. wallichii.* The lamellæ forming the refractive border at the proximal end and sides gradually become sharply defined and striated, bnt usually gelatinize without breaking into refractive granules; this border is more resistant than in most grains of *P. wallichii.* The gelatinized grains are swollen and distorted, usually less at the proximal end than in both parents. They do not resemble the untreated grain as in both parents. The reactions are closer to those of *P. grandifolius* than to those of the other parent.

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 81 per cent of the grains and 95 per cent of the total starch in 2 minutes; in about 95 per cent of the grains and over 99 per cent of the total starch in 5 minutes. (Chart D 583.) The reaction is so rapid that the minute steps can not be determined as in both parents.

The gelatinized grains are much swollen and distorted, more irregularly distorted, especially at the distal corners of many grains, and fewer telescoped throughout with concave invagination than in *P. grandifolius;* not quite so distorted at the distal corners, and a considerably larger number telescoped throughout with concave invagination than in *P. wallichii.* When the proximal end is not distorted, the wall at this point is quite as thick as in *P. grandifolius,* and thicker than in *P. wallichii.* The gelatinized grains do not resemble the form of the untreated grain, as in both parents. The reactions are closer to those of *P. grandifolius* than to those of the other parent.

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 62 per cent of the entire number of grains and 84 per cent of the total starch in 2 minutes; in about 75 per cent of the grains and 95 per cent of the total starch in 5 minutes; in about 98 per cent of the grains and 99 per cent of the total starch in 15 minutes. (Chart D 584.)

A bubble appears more frequently and enlarges to greater size than in both parents. The lamellæ become sharply defined and striated, about as in *P. grandifolius,* but with somewhat sharper definition than in *P. wallichii.* Fissures of a similar character to those of both parents are formed; they are more frequent and also more often branched than in *P. grandifolius;* but not nearly so frequent or branched as in *P. wallichii.* The lamellæ of the different regions of the grain are disorganized about as in both parents; a group of large very refractive granules appear near the hilum about as frequently as in *P. grandifolius,* but more often than in *P. wallichii.* Gelatinization less frequently begins at the proximal end, and the refractive border at this end and sides is usually broader than in both parents. The reaction usually starts from the hilum and proceeds distalward through the grain, the refractive border at the proximal end and sides being the most resistant. The corners of the distal margin gelatinize with more irregular distortion than in *P. grandifolius,* but not in nearly so many grains as in *P. wallichii.* The gelatinized grains are much swollen and distorted, the distal margin is somewhat more distorted than in *P. grandifolius,* but considerably less than in *P. wallichii;* the proximal end is less distorted than in both parents. The gelatinized grain does not resemble the form of the untreated grain as in both parents. The reactions are closer to those of *P. grandifolius* than to those of the other parent.

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 58 per cent of the grains and 90 per cent of the total starch in 2 minutes; in about 83 per cent of the grains and 95 per cent of the total starch in 5 minutes; in about 96 per cent of the grains and 99 per cent of the total starch in 15 minutes. (Chart D 585.)

A bubble appears at the hilum as in both parents. The lamellæ become sharply defined and striated as in both parents. Fissures form somewhat more frequently than in *P. grandifolius,* but less frequently than in *P. wallichii.* Gelatinization begins and progresses in the less resistant grains as in both parents, but more closely follows the process in *P. grandifolius* than that in *P. wallichii.* The more resistant grains react as in both parents, being about as numerous as in *P. grandifolius,* but more numerous than in *P. wallichii.* The reaction is so rapid that no more minute differences can be detected.

The gelatinized grains are much swollen and distorted, somewhat more distorted, and more with extension at the proximal end than in *P. grandifolius;* but less distorted, and not so many with proximal end extended, as in *P. wallichii.* The gelatinized grains do not resemble the untreated grains as in both parents. The reactions are closer to those of *P. grandifolius* than to those of the other parent.

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 43 per cent of the entire number of grains and 54 per cent of the total starch in 5 minutes; in about 91 per cent of the grains and 96 per cent of the total starch in 15 minutes; in about 99 per cent of the grains and over 99 per cent of the total starch in 30 minutes. (Chart D 586.)

The hilum becomes distinct and a small bubble is formed there as frequently as in *P. wallichii,* but the folds or wrinkles in the capsule are not noted so frequently as in that starch, but more frequently than in *P. grandifolius.* The lamellæ are as distinct as in *P. grandifolius,* and later become indistinct as in that starch. A refractive band as broad and refractive as in the grains of *P. grandifolius* is formed quickly about the margin of the grain. Gelatinization begins usually at the distal end as in *P. grandifolius,* and occasionally at the proximal as in *P. wallichii.* The progress of gelatinization is similar to that described under *P. grandifolius,* except that the margin is less resistant than in that starch, but more resistant than in *P. wallichii,* the most resistant portion is found, usually, just distal to the hilum as in *P. grandifolius.* The gelatinized grains are large and very much distorted, but retain some resemblance to the untreated grain. In this reaction *P. hybridus* qualitatively shows a closer relationship to *P. grandifolius* than to *P. wallichii.*

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 58 per cent of the entire number of grains and 75 per cent of the total starch in 5 minutes; in about 88 per cent of the grains and 99 per cent of the total starch in 15 minutes; in about 97 per cent of the grains and over 99 per cent of the total starch in 30 minutes. (Chart D 587.)

The reaction with *uranium nitrate* begins in 30 seconds. Complete gelatinization occurs in about 32 per cent of the entire number of grains and 68 per cent of the total starch in 5 minutes; in about 70 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 90 per cent of the grains and 98 per cent of the total starch in 30 minutes; little if any further advance is observed in 45 and 60 minutes, respectively. (Chart D 588.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 75 per cent of the entire number of grains and 83 per cent of the total starch in 2 minutes; in about 97 per cent of the grains and 98 per cent of the total starch in 5 minutes; in 100 per cent of both the grains and total starch in 10 minutes. (Chart D 589.)

The reaction with *cobalt nitrate* begins in a few grains in 1 minute. Complete gelatinization occurs in

about 3 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 20 per cent of the grains and 62 per cent of the total starch in 15 minutes; in about 33 per cent of the grains and 76 per cent of the total starch in 30 minutes; in about 51 per cent of the grains and 82 per cent of the total starch in 45 minutes; in about 52 per cent of the grains and 86 per cent of the total starch in 60 minutes. (Chart D 590.)

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 80 per cent of the entire number of grains and 98 per cent of the total starch in 5 minutes; in about 95 per cent of the grains and over 99 per cent of the total starch in 10 minutes; in about 97 per cent of the grains and over 99 per cent of the total starch in 15 minutes. (Chart D 591.)

The reaction with *cupric chloride* begins in a few grains immediately. Complete gelatinization occurs in about 18 per cent of the grains and 65 per cent of the total starch in 5 minutes; in about 50 per cent of the grains and 82 per cent of the total starch in 15 minutes; in about 67 per cent of the grains and 92 per cent of the total starch in 30 minutes; in about 80 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 82 per cent of the grains and 96 per cent of the total starch in 60 minutes. (Chart D 592.)

The reaction with *barium chloride* begins in a few grains in 30 seconds. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 1 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 3 per cent of the total starch in 15 minutes; a slight advance in the grains and 5 per cent of the total starch in 30 minutes; in about 2 per cent of the grains and 6 per cent of the total starch in 45 minutes; in about 3 per cent of the grains and 8 per cent of the total starch in 60 minutes. (Chart D 593.)

The reaction with *mercuric chloride* begins in a few grains immediately. Complete gelatinization occurs in about 18 per cent of the entire number of grains and 68 per cent of the total starch in 5 minutes; in about 45 per cent of the grains and 85 per cent of the total starch in 15 minutes; in about 61 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 63 per cent of the grains and 95 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 594.)

15. MILTONIA.

This genus of orchids includes a dozen or more well-known species, and there are as many hybrids and also many varieties. Starches from the pseudobulbs of the following parent-stocks and hybrid-stocks were studied:

43. *M. vexillaria* Nichols (*Odontoglossum vexillarium* Reichb. f.) (seed parent), *M. rœzlii* Nichols (*Odontoglossum rœzlii* Reichb. f.) (pollen parent), and *M. bleuana* (hybrid). The parent-stocks are closely allied, differing only in minor respects.

The specimens were obtained from Sander and Sons, St. Albans, England.

43. Starches of Miltonia vexillaria, M. rœzlii, and M. bleuana.

Miltonia vexillaria (Seed Parent).

(Plate 24, fig. 139; Charts D 595 to D 615.)

Histologic Properties.

In *form* the grains are mostly simple, and also isolated with the exception of a moderately large proportion which appear in aggregates of usually 2 to 4, rarely 12, components, forming a rounded mosaic. Compound grains are occasionally present, and usually consist of from 2 to 3 components. Well-defined pressure facets are found on many grains. The outline of the grains is frequently irregular, which is chiefly due to the following causes: Shifting of the longitudinal axis; inequalities in the surface varying from slight to concave indentations; variation in the contour of the sides, especially noted in dome-shaped grains in which one side is much more slanting than the other; irregularity of the pressure facet of dome-shaped grains; a small protuberance which may be located at varying points on the surface; and to a rounded unilateral swelling which appears to be composed of a secondary set of lamellæ. The most conspicuous forms of the isolated grains of the disaggregate-type are ovoid, sometimes with squared distal end, round, ellipsoidal, pyriform, and almost round. The additional forms of this type are oyster-shell-shaped; elongated, narrow ovoid; low triangular which may have either rounded or concave distal corners; and grains of indefinite shape. The conspicuous forms among the isolated grains of the aggregate type are dome-shaped with either squared, pointed, diagonal or slightly irregular distal end; bell-jar-shaped with either squared or concave distal end; ovoid with concave distal end; and quadrangular with curved sides. The most conspicuous forms of the aggregates are doublets with components of about equal size; 1 large component, either ovoid or pyriform, with 1 moderate-sized component at 1 of the distal corners; 3 moderate-sized components in linear arrangement, the middle being the largest; 1 large component with 1 moderate-sized component at the distal corners; and 4 components in compact arrangement. The grains are not usually flattened.

The *hilum* is often fissured, but sometimes it may be observed as either a small, lenticular or round, non-refractive to quite refractive spot, this spot probably representing a cavity. Either a small rounded or irregular cavity is occasionally present. It varies in position from centric to quite eccentric. The clefts at the hilum are quite varied in structure, chiefly among which are the following: 1 short, transverse, often somewhat bent; 1 short diagonal; a cluster of irregularly arranged fissures; and thorn-shape. Fissures often project from the hilum or the clefts thereat, and with the latter may form a cruciate, a soaring-bird, or a Y-shaped figure, the latter either upright or inverted; either 2 short fissures sometimes pass from either side of the hilum and are directed obliquely toward the distal corners, or 1 branched longitudinal fissure may pass from the center of the hilum and not infrequently be slightly diagonal, probably due to shifting of the longitudinal axis. In the dome-shaped grains 2 fissures pass from either side of the hilum and are directed obliquely toward the distal corners, 1 frequently being much longer and deeper than the other,

apparently related to the difference in the contour of the sides. The eccentricity of the hilum varies from 0.44 to 0.11, commonly 0.25 to 0.16, of the longitudinal axis.

The *lamellæ* in the smaller and medium-sized grains are frequently indistinct, with the exception of one which is moderately coarse and refractive; but in the larger grains they can usually be observed over the greater part of the grain, and are moderately fine with the exception of 1 or 2 which are broader and often quite refractive. They are frequently less distinct for about one-third of the distance from the hilum, although in some grains either a circular or lenticular ring may be detected around the hilum; over most of the grain, however, they closely follow the outline, becoming flattened or irregular toward the distal end, according to the character of the grain at that margin. A refractive band in which the lamellæ are usually indistinct is frequently found separated from the main body of the grain by a moderately coarse and quite refractive lamella. This refractive band may form either a border around the entire grain or a band across the distal margin which may extend unilaterally toward the proximal end. In some moderate-sized, ellipsoidal grains this band may form a marginal border with lateral extension at the distal margin, not infrequently being greater at one corner than the other; the lamellæ in this case, while fine, are generally demonstrable. The bands above noted probably represent a secondary set of lamellæ. A secondary set of lamellæ placed at about a right angle to the primary set is occasionally observed. The direction of the lamellæ is occasionally shifted, and since there is not always a definite line of demarcation such as one coarser refractive lamella or a change in the character either from fine to coarse or in the degree of refractivity, it could not be determined whether or not this is caused by depositions at different periods or by a change in the longitudinal axis during one period.

The *size* of the grains varies from the smaller which are 4 by 3μ, to the larger which are 36 by 24μ, commonly about 24 by 18μ, in length and breadth.

Polariscopic Properties.

The *figure* is clean-cut and varies from centric to quite eccentric, with a larger proportion of the eccentric type. The lines are usually fine and generally intersect either at a right angle or obliquely, but sometimes are so arranged as to form an elongated, median line with bisected ends. The lines may be straight, but are frequently bent and sometimes bisected. Double and multiple figures are moderately common, consisting of both the aggregate and compound type.

The *degree of polarization* is high to very high (value 85). A few grains show a variation in the same aspect of a given grain.

With *selenite* the quadrants are usually sharply defined, generally unequal in size, and frequently slightly irregular in shape. The colors are generally pure, but occasionally impurity appears at both ends of the scale, namely orange and purplish, and with a greenish tinge to both colors.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains color a moderate blue-violet (value 55), which deepens rapidly to a very deep blue. With 0.125 per cent Lugol's solution the grains color a light blue-violet, which deepens rapidly and becomes bluer in tint; there is more variation in the depth of the individual grains with this solution than with the former. After heating in water until all the grains are gelatinized and then adding 2 per cent Lugol's solution, most of the *grains* color a moderately deep blue, some with a slight reddish tint, and the *solution* a moderately deep blue with slight greenish tint. If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* (which are very few in number) color a light to moderate blue with reddish tint, and most of the *capsules* a deep old-rose to wine-red, a few amethyst or reddish-heliotrope, and the *solution* a deep blue.

Aniline Reactions.

With *gentian violet* the grains color very lightly at once, and in 30 minutes they are moderately stained, with rare grains moderately deep (value 50). One lamella is often deeper in color than the rest of the grain, sometimes the border distal to it being lighter than the main body of the grain.

With *safranin* the grains immediately stain lightly, a little deeper than with gentian violet, and in half an hour they are moderate to moderately deep in color (value 55), a little deeper than with gentian violet. The same variation in the depth of 1 lamella is noted as with gentian violet.

Temperature Reactions.

The temperature of gelatinization of the majority of grains is at 70° to 71° C., and of all but rare resistant grains at 73° to 74° C., mean 73.5° C. The mesial portion of the grain is much less resistant than a few marginal lamellæ; this central portion being gelatinized in practically all the grains at 65° to 67° C., but the marginal lamellæ resist the process until the temperature of 73° to 74° C. is reached.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 51 per cent of the entire number of grains and 67 per cent of the total starch in 5 minutes; in about 75 per cent of the grains and 84 per cent of the total starch in 15 minutes; in about 87 per cent of the grains and 97 per cent of the total starch in 30 minutes; in about 90 per cent of the grains and 98 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 595.)

The hilum becomes distinct, and sometimes a bubble is formed there. The lamellæ are distinct at first, but later become obscured. A broad refractive space forms at the distal margin, but does not extend completely around the grain. Gelatinization begins in most grains at the distal margin by means of small cracks that invade the grain from the margin; this is followed in many grains by swelling of the hilum and rapid gelatinization of the proximal end. In other grains the proximal end is not affected until the end of the reaction, and in still others the proximal end is affected first and the distal end last. In the first method, gelatinization proceeds rather unevenly from the initial points, the grain assuming a pitted and often a granular appearance just preceding gelatinization, and granules are separated from this mass and gelatinized. Usually the margin is less

resistant than the central portion and sometimes the margin on one side is less resistant than on the other. The part of the grain just distal to the hilum is usually the most resistant, and this is at the last usually split into 2 or 3 pieces which are widely separated and then gelatinized. The gelatinized grains are very large and greatly distorted, and do not retain much of the form of the untreated grain.

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 9 per cent of the entire number of grains and 42 per cent of the total starch in 5 minutes; in about 45 per cent of the grains and 87 per cent of the total starch in 15 minutes; in about 90 per cent of the grains and 99 per cent of the total starch in 30 minutes; in more than 99 per cent of both the grains and total starch in 45 minutes. (Chart D 596.)

The hilum becomes very distinct and a bubble is not observed to form there. The lamellæ are at first distinct, but later are obscured for a time, then become distinct again. Gelatinization begins at the hilum which enlarges somewhat, and the grain at the same time is divided by fine striæ radiating from the hilum. The starch immediately distal to the hilum is divided into coarse granules by branching fissures, 2 or 3 of which are extended to the distal margin, the surface of this part of the grain at the same time assuming a pitted appearance which obscures the lamellæ. From this point, three methods of gelatinization may be observed. According to the first method, in the less resistant grains the hilum enlarges more rapidly toward the proximal end, and the starch at this point is rapidly gelatinized until only the capsule remains, and this is soon dissolved and the semifluid gelatinous material, which it has inclosed, flows out, leaving a granular mass at the distal end, which slowly gelatinizes and also dissolves. The second method differs from the first only in that a lamellated marginal band limited on the inside by coarse granules is formed about the entire margin of the grain and, as this becomes uniformly thinner and more nearly transparent, the capsule is dissolved in several places, and the remaining ungelatinized starch separates into several pieces, gelatinizes, and dissolves. According to the third method the lamellar structure which is obscured by fissures, becomes again visible in the form of rows of granules, while the space representing the enlarged hilum is occupied by irregularly placed, coarse granules which as the reaction advances become more and more nearly transparent, then from the hilum to within 2 or 3 lamellæ of the margin the whole starch of the grain rapidly gelatinizes, while the 2 or 3 lamellæ remaining form a distinct, narrow, striated, marginal band which becomes thinner and more nearly transparent, especially at the distal end, and finally the capsule is dissolved at this point, the gelatinized starch flows out and is dissolved, and the rest of the starch at the proximal end is quickly gelatinized.

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 17 per cent of the grains and 50 per cent of the total starch in 5 minutes; in about 37 per cent of the grains and 72 per cent of the total starch in 15 minutes; in about 59 per cent of the grains and 84 per cent of the total starch in 30 minutes; in about 72 per cent of the grains and 90 per cent of the total starch in 45 minutes; in about 82 per cent of the grains and 94 per cent of the total starch in 60 minutes. (Chart D 597.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 67 per cent of the entire number of grains and 88 per cent of the total starch in 1 minute; in about 74 per cent of the grains and 92 per cent of the total starch in 2 minutes; in about 84 per cent of the grains and 97 per cent of the total starch in 5 minutes; in about 93 per cent of the grains and 99 per cent of the total starch in 15 minutes; in about 96 per cent of the grains and in more than 99 per cent of the total starch in 30 minutes. (Chart D 598.)

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 97 per cent of the entire number of grains and over 99 per cent of the total starch in 1 minute; in all but parts of rare grains, over 99 per cent of both the grains and total starch in 1 minute and 30 seconds; complete gelatinization (100 per cent) of all grains in 2 minutes. (Chart D 599.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 84 per cent of the entire number of grains and 97 per cent of the total starch in 1 minute; in about 95 per cent of the grains and over 99 per cent of the total starch in 2 minutes; all grains are completely gelatinized with the exception of parts of the margin of a few; in about 99 per cent of the grains and in over 99 per cent of the total starch in 5 minutes. (Chart D 600.)

The hilum becomes very distinct and a rather large bubble is sometimes formed there, and if any fissures are present in the untreated grain they become wider and more extensive, but do not in any case extend to the margin. The lamellæ become very distinct and remain so until the end of the reaction is nearly reached. Gelatinization begins at the hilum which enlarges, and the bubble, if present, swells, then shrinks and disappears; and fine striæ appear radiating from the hilum throughout the grain to the margin, and these become less fine and more distinct as gelatinization progresses. The starch just distal to the hilum is divided into coarse granules by irregular fissures, and the more resistant starch, as the hilum enlarges and the grain swells, is pushed to the margin where it forms a very distinctly lamellated and striated band, the inner lamella of which is divided into a regular row of granules, while just within this at the distal end is the collection of coarse granules formed from the material just distal to the hilum. The whole marginal band and the granules become thinner and more nearly transparent until finally all the intracapsular starch is gelatinized and only the thin capsule remains.

The gelatinized grains are large and at first are not much distorted except at the distal end, but later they become thin-walled and considerably distorted, and do not retain much of the form of the untreated grain.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 82 per cent of the entire number of grains and 98 per cent of the total starch in 1 minute; in about 93 per cent of the grains and in over 99 per cent of the total starch in 5 minutes; in about 95 per cent of the grains and in over 99 per cent of the total starch in 10 minutes; complete gelatinization (100 per cent) in 15 minutes. (Chart D 601.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 48 per cent of the entire number of grains and 84 per cent of the total starch in 5 minutes; in about 84 per cent of the grains and 97 per cent of the total starch in 15 minutes; in about 95 per cent of the grains and in over 99 per cent of the total starch in 30 minutes. (Chart D 602.)

The hilum becomes very distinct, as do the lamellæ. Gelatinization begins at the hilum which enlarges somewhat, and numerous branching fissures extend from the hilum to the distal end, along the course of which the starch loses its lamellar structure and becomes finely granular, while around the proximal margin and sides a very clearly defined, lamellated band of resistant starch is formed. The granular portion of the grain is gelatinized first, with considerable distention and then infolding of the capsule; the marginal band slowly becomes thinner and more nearly transparent until only the thin capsule is left. In the small grains and some of the large grains granulation of one part does not take place, but a marginal band is formed around the whole margin, and these grains are less distorted than those first described. The gelatinized grains are large, thin-walled, and often more distorted at the distal end. They do not retain much of the form of the untreated grain.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 67 per cent of the entire number of grains and 95 per cent of the total starch in 2 minutes; in about 90 per cent of the grains and 99 per cent of the total starch in 5 minutes; in about 98 per cent of the grains and in more than 99 per cent of the total starch in 15 minutes. (Chart D 603.)

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 53 per cent of the entire number of grains and 83 per cent of the total starch in 5 minutes; in about 57 per cent of the grains and 87 per cent of the total starch in 15 minutes; in about 59 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 73 per cent of the grains and 92 per cent of the total starch in 45 minutes; in about 80 per cent of the grains and 95 per cent of the total starch in 60 minutes. (Chart D 604.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 78 per cent of the grains and 95 per cent of the total starch in 5 minutes; in about 96 per cent of the grains and in 99 per cent of the total starch in 15 minutes. (Chart D 605.)

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 43 per cent of the grains and 79 per cent of the total starch in 5 minutes; in about 71 per cent of the grains and 89 per cent of the total starch in 15 minutes; in about 83 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 86 per cent of the grains and 96 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 606.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 67 per cent of the entire number of grains and 80 per cent of the total starch in 5 minutes; in about 97 per cent of the grains and 98 per cent of the total starch in 15 minutes. (Chart D 607.)

The hilum becomes very distinct and a small bubble is moderately often formed there. The lamellæ become distinct and remain so until gelatinized. A broad but not very refractive band is quickly formed about the margins of the grains. Gelatinization begins at two or three places on the distal margin, at which points small cracks have invaded the grain, and in some grains the hilum and proximal end are gelatinized immediately following this beginning, but in most of the grains this does not take place until after at least a third of the distal starch has been gelatinized. Gelatinization proceeds moderately smoothly and rather more rapidly around the margin than in the central part of the grain, the part just distal to the hilum being the most resistant in some grains; when the rest of the starch has been gelatinized, this part is split into two pieces by a fissure running from the hilum distally, and these two pieces are rapidly gelatinized. In most of the grains, however, it is not so split, but gelatinizes as a whole, and in a moderate number of grains the proximal end is the last to be gelatinized. The gelatinized grains are much enlarged, with somewhat thick capsules, and much distorted. They do not retain much of the form of the untreated grain.

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 25 per cent of the entire number of grains and 84 per cent of the total starch in 5 minutes; in about 68 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 80 per cent of the grains and 96 per cent of the total starch in 30 minutes; in about 82 per cent of the grains and 97 per cent of the total starch in 45 minutes; in about 90 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 608.)

The reaction with *uranium nitrate* begins immediately. Complete gelatinization occurs in about 42 per cent of the entire number of grains and 83 per cent of the total starch in 5 minutes; in about 59 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 95 per cent of the total starch in 10 minutes; in about 74 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 85 per cent of the grains and 96 per cent of the total starch in 45 minutes; in about 90 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 609.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 70 per cent of the entire number of grains and 91 per cent of the total starch in 5 minutes; in about 95 per cent of the grains and 99 per cent of the total starch in 15 minutes; in about 98 per cent of the grains and in more than 99 per cent of the total starch in 30 minutes. (Chart D 610.)

The reaction with *cobalt nitrate* begins in a few grains in 30 seconds. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 16 per cent of the total starch in 5 minutes; in about 16 per cent of the grains and 46 per cent of the total starch in 15 minutes; in about 18 per cent of the grains and 52 per cent of the total starch in 30 minutes; in about 28 per cent of the grains and 56 per cent of the total starch in 45 minutes; in about 32 per cent of the grains and 60 per cent of the total starch in 60 minutes. (Chart D 611.)

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 52 per cent of the grains and 84 per cent of the total starch in 5 minutes; in about 76 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 83 per cent of the grains and 96 per cent of the total starch in 30 minutes; in about 89 per cent of the grains and 97 per cent of the total starch in 45 minutles; in about 93 per cent of the grains and in over 99 per cent of the total starch in 60 minutes. (Chart D 612.)

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 17 per cent of the entire number of grains and 56 per cent of the total starch in 5 minutes; in about 30 per cent of the grains and 70 per cent of the total starch in 15 minutes; in about 36 per cent of the grains and 78 per cent of the total starch in 30 minutes; in about 45 per cent of the grains and 81 per cent of the total starch in 45 minutes; in about 57 per cent of the grains and 85 per cent of the total starch in 60 minutes. (Chart D 613.)

The reaction with *barium chloride* begins in a few grains immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 2 per cent of the total starch in 5 minutes; in about 2 per cent of the grains and 6 per cent of the total starch in 15 minutes; in about 4 per cent of the grains and 7 per cent of the total starch in 30 minutes; in about 5 per cent of the grains and 10 per cent of the total starch in 45 minutes; in about 40 per cent of the grains and 75 per per cent of the total starch in 60 minutes. (Chart D 614.)

The reaction with *mercuric chloride* begins immediately. Complete gelatinization occurs in about 16 per cent of the entire number of grains and 43 per cent of the total starch in 5 minutes; in about 27 per cent of the grains and 60 per cent of the total starch in 15 minutes; in about 40 per cent of the grains and 75 per cent of the total starch in 30 minutes; in about 49 per cent of the grains and 80 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 85 per cent of the total starch in 60 minutes. (Chart D 615.)

Miltonia rœzlii (Pollen Parent).

(Plate 24, fig. 140; Charts D 595 to D 615.)

Histologic Properties.

In *form* most of the grains are simple and isolated, with the exception of a moderately large proportion (about as in *M. vexillaria*) which appear in aggregates of usually from 2 to 6, occasionally 20, components in mosaic arrangement. Compound grains are present, but are somewhat less numerous than in *M. vexillaria*. Well-defined pressure facets are present as in *M. vexillaria*. The surface of the grains is generally irregular, and the irregularities are more pronounced and appear in many more grains than in *M. vexillaria*. The irregularities are generally due to the same causes as in *M. vexillaria*, but the shifting of the longitudinal axis is much more frequent and sometimes so sharp as to result in an abrupt bending of the grain; the protuberances are often larger, sometimes drawn out into a point at the proximal end, and occur with more frequency; the outline is irregular in many more grains, sometimes becoming undulating at one end; a somewhat abrupt flaring may occur at the distal margin, this not being observed in *M. vexillaria;* and secondary, tertiary, or irregularly placed groups of lamellæ are much more common and varied in arrangement, which result in greater variation of the contour of the sides of the grain. The conspicuous forms of the isolated grains of the disaggregate type are ovoid, sometimes squared at distal end; pyriform; low triangular with curved sides and rounded angles; nearly round; ellipsoidal; and high triangular with curved sides and rounded angles. The additional forms are broad lenticular, one side less curved than the other; slender pyriform, sometimes slightly curved to one side; round, oyster-shell-shaped; quadrangular with curved sides and rounded angles; triangular with convex distal end (base) and concave sides; potato-tuber-shaped; and grains of indefinite form. The most conspicuous forms among the isolated grains of the aggregate type are dome-shaped, either with squared, pointed or diagonal, or slightly irregular distal end (base); finger-shaped with either concave or slightly irregular distal end; bell-jar-shaped with either squared or concave distal end; and grains of indefinite shape. The conspicuous forms of the aggregates are doublets composed of about equal components; potato-tuber-shaped; a mosaic of varying number of components, doublets and triplets consisting of 1 large and either 1 or 2 moderate-sized components, the latter usually located at the proximal end; and rounded mosaics of varying numbers of components. The aggregates are more varied with a larger number of mosaic type than in *M. vexillaria*. The grains are not usually flattened, although when a secondary set of lamellæ is present some flattening is observed; this occurs more frequently than in *M. vexillaria.*

The *hilum* is somewhat more frequently fissured than in *M. vexillaria,* but when unfissured is less distinct than in *M. vexillaria*. It can occasionally be made out as either a small, lenticular or round spot, which varies from non-refractive to quite refractive, as in *M. vexillaria,* the latter being even more rare than in that species. The position varies from centric to quite eccentric. Either a small, irregular or lenticular cavity, usually directed longitudinally, is sometimes observed, somewhat more frequently than in *M. vexillaria*. The cleft or clefts at the hilum appear somewhat more frequently, but are of about the same character as in *M. vexillaria,* the cluster of irregularly placed clefts is, however, more commonly present than in that species. The fissures which project from the hilum are similar to those of *M. vexillaria,* but are generally deeper, and the median fissure while directed as in *M. vexillaria* is deeper, more frequently branched, and much more commonly observed. The eccentricity of the hilum varies from 0.46 to 0.11, commonly 0.33 to 0.2, of the longitudinal axis, less than in the other parent.

The *lamellæ* are less often demonstrable, but when observed they have the same general characteristics as in *M. vexillaria*. The border with laterally extended distal corners surrounding an ellipsoidal grain is much more commonly observed. A definite secondary set of lamellæ, placed at a right angle with the primary set, is much more frequently present than in *M. vexillaria*. The direction of the lamella is more frequently changed than in *M. vexillaria,* sometimes three or more groups may vary in this respect as well as sometimes in width, refractivity, etc.; more groups occur, they vary more in character, and

are much more often present than in *M. vexillaria;* as in that species it could not be determined whether or not they always represent depositions at different periods, or whether they are caused by a shifting of the longitudinal axis during 1 period. The number counted on the larger grains varies from 26 to 38, more often the former.

The *size* of the grains varies from the smaller which are 6 by 5μ, to the larger elongated, which are 40 by 30μ, and the broadened 34 by 50μ; the common size of the elongated is about 30 by 24μ and of the broadened 24 by 26μ, in length and breadth. The size is larger than in the other parent and with a marked tendency to broadness.

Polariscopic Properties.

The *figure* is not quite as clean-cut as in *M. vexillaria,* varies from centric to quite eccentric, with a smaller proportion of the eccentric type than in *M. vexillaria,* thus making the mean less eccentric. The lines vary from fine to coarse, the mean being coarser than in *M. vexillaria;* they intersect as in *M. vexillaria,* but the arrangement of a median line with bisected ends is more frequent. The lines are more often bent than straight and also frequently bisected; both occur with greater frequency than in *M. vexillaria.* Double and multiple figures of both the aggregate and the compound type are present as in *M. vexillaria.*

The *degree of polarization* is moderate to very high (value 75), the mean being lower than in *M. vexillaria* because the variation is greater, although somewhat more of the very high grains are present than in *M. vexillaria.* A greater variation is also found in the same aspect of a given grain.

With *selenite* the quadrants vary from moderately to sharply defined, less clean-cut than in *M. vexillaria;* they are generally unequal in size and vary from slightly to very irregular in shape, more irregular than in *M. vexillaria.* The blue is generally pure, but the yellow is frequently not pure throughout the entire quadrant; and the impurity is at both ends of the scale as in *M. vexillaria,* but the proportion of the purplish and orange is considerably greater, while that of the greenish tinge is slightly greater, hence the mean places the impurity of the colors lower than in *M. vexillaria.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains color a moderate blue-violet (value 50), which, however, is a little lighter and more reddish, than in *M. vexillaria.* The color deepens rapidly but is more varied in depth of the individual grains and also becomes neither so deep nor so bluish as in *M. vexillaria.* With 0.125 per cent Lugol's solution the grains color a light violet which is a little lighter and more reddish than in *M. vexillaria;* the color deepens with greater variation, and also becomes neither so deep nor so bluish as in *M. vexillaria.* After heating in water until all the grains are gelatinized and then adding iodine, the gelatinized *grains* color a moderately deep to deep blue, some with reddish tint, deeper and a little more reddish than in *M. vexillaria.* The *solution* becomes a deep indigo-blue, deeper and purer than in *M. vexillaria.* If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* (somewhat more numerous than in *M. vexillaria*) become a moderately deep blue, all with reddish tint, deeper than in *M. vexillaria;* and the *capsules* vary from an amethyst or light reddish-heliotrope to deep reddish-heliotrope or rarely a wine-red—they are deeper and less reddish than in *M. vexillaria.* The *solution* is a little deeper than in *M. vexillaria.*

Aniline Reactions.

With *gentian violet* the grains immediately color very lightly, and in 30 minutes they are moderate to moderately deep in color (value 55), more of the latter than in *M. vexillaria,* hence making the mean deeper. The one lamella stains more deeply than the other parts of the grain, as in *M. vexillaria.*

With *safranin* the grains immediately color lightly, a little deeper than with gentian violet, and in 30 minutes they are moderate to deep in color (value 65), considerably deeper than in *M. vexillaria.* The one lamella colors more deeply with this reagent as with gentian violet.

Temperature Reactions.

The temperature of gelatinization of the majority of grains is at 74° to 76° C., and of all but rare resistant grains at 76° to 77° C., mean 76.5° C. The central portion of the grains of this species is much more easily gelatinized than the marginal lamellæ, as in *M. vexillaria.* This mesial portion of practically all the large grains is gelatinized at 67° to 69° C., mean 68° C., but several small grains are little affected, as well as the marginal lamellæ of the large grains, at this temperature.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 50 per cent of the grains and 60 per cent of the total starch in 5 minutes; in about 66 per cent of the grains and 71 per cent of the total starch in 15 minutes; in about 81 per cent of the grains and 82 per cent of the total starch in 30 minutes; in about 76 per cent of the grains and 84 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 595.)

The hilum is, usually, as distinct as in *M. vexillaria,* but in some grains it is not distinct. The lamellæ are usually not distinct, but can be seen in some grains. A refractive space is noted at the distal margin as in *M. vexillaria,* but it is not so broad or so refractive, as in those grains. Gelatinization differing from *M. vexillaria* begins at many points on the margin, or, as in *M. vexillaria,* it begins at the distal margin and then at the proximal end. The progress of gelatinization is much the same as in *M. vexillaria,* except that it is more irregular, more granules are formed and split off, and the greater part of the grain may be split by fissures into several pieces which gelatinize separately. The grains are large and more distorted than those of *M. vexillaria.*

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 6 per cent of the entire number of grains and 37 per cent of the total starch in 5 minutes; in about 20 per cent of the grains and 71 per cent of the total starch in 15 minutes; in about 70 per cent of the grains and 96 per cent of the total starch in 30 minutes; in about 95 per cent of the grains and in over 99 per cent of the total starch in 45 minutes. (Chart D 596.)

The hilum becomes as distinct as in *M. vexillaria,* and the lamellæ are not so distinct as in those grains. Gelatinization as in *M. vexillaria* begins at the hilum, which enlarges somewhat; and in many compound grains wide fissures, which apparently have no connection with the hilum, split the starch of the grains into several portions which probably represent the components, without, however, breaking the capsule, and gelatinization proceeds in these pieces as it does in the simple grains. The process is very nearly the same as in *M. vexillaria,* except that the lamellar structure of the starch after granulation is not so obvious and more coarse granules are formed immediately about the hilum. Solution of the capsule usually takes place at the proximal end much more frequently than in *M. vexillaria.*

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 15 per cent of the entire number of grains and 43 per cent of the total starch in 5 minutes; in about 28 per cent of the grains and 63 per cent of the total starch in 15 minutes; in about 37 per cent of the grains and 72 per cent of the total starch in 30 minutes; in about 40 per cent of the grains and 77 per cent of the total starch in 45 minutes; in about 50 per cent of the grains and 80 per cent of the total starch in 60 minutes. (Chart D 597.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 48 per cent of the entire number of grains and 86 per cent of the total starch in 1 minute; in about 68 per cent of the grains and 93 per cent of the total starch in 2 minutes; in about 75 per cent of the grains and 95 per cent of the total starch in 5 minutes; in about 88 per cent of the grains and 97 per cent of the total starch in 15 minutes; in about 93 per cent of the grains and 99 per cent of the total starch in 30 minutes. (Chart D 598.)

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 89 per cent of the entire number of grains and 97 per cent of the total starch in 1 minute; in about 95 per cent of the grains and 98 per cent of the total starch in 2 minutes; in all but parts of rare grains, and in over 99 per cent of both the grains and total starch in 4 minutes; complete gelatinization (100 per cent) of all grains in 5 minutes. (Chart D 599.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 70 per cent of the entire number of grains and 94 per cent of the total starch in 1 minute; in about 78 per cent of the grains and 97 per cent of the total starch in 2 minutes; in about 94 per cent of the grains and in over 99 per cent of the total starch in 5 minutes. (Chart D 600.)

The hilum usually becomes distinct, and no bubble formation is noted. If fissures exist at the hilum or elsewhere in the grain they widen and deepen, and in the compound grains sometimes reach the capsule but do not break it. The lamellæ are not so distinct as in *M. vexillaria* and do not, in every grain, remain distinct throughout the reaction. Gelatinization, as in *M. vexillaria,* begins at the hilum, and the progress is very similar to that in *M. vexillaria,* except that the whole interior of the grain, excepting 2 or 3 lamellæ at the margin, becomes coarsely granular, and the lamellar structure in the marginal band is not nearly so distinct. The gelatinized grains are thicker walled than in *M. vexillaria,* and later become thin-walled and are more distorted than in this starch.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 97 per cent of the entire number of grains and in over 99 per cent of the total starch in 1 minute; complete gelatinization of all the grains (100 per cent) occurs in 5 minutes. (Chart D 601.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 50 per cent of the entire number of grains and 75 per cent of the total starch in 5 minutes; in about 60 per cent of the grains and 85 per cent of the total starch in 15 minutes; in about 77 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 80 per cent of the grains and 92 per cent of the total starch in 45 minutes; in about 82 per cent of the grains and 95 per cent of the total starch in 60 minutes. (Chart D 602.)

The hilum becomes as distinct as in *M. vexillaria,* but the lamellæ are not so distinct. Gelatinization as in *M. vexillaria* begins at the hilum and the progress is much the same as in those grains, except that granulation is more extensive and the granules are not so fine, while an indistinctly lamellated band often extends completely around even those grains in which fissuration and granulation have taken place. The gelatinized grains are large, thin-walled, and more distorted than those of *M. vexillaria,* and retain less resemblance to the form of the untreated grain.

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 50 per cent of the entire number of grains and 85 per cent of the total starch in 2 minutes; in about 70 per cent of the grains and 89 per cent of the total starch in 5 minutes; in about 85 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 90 per cent of the grains and 98 per cent of the total starch in 30 minutes. (Chart D 603.)

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 36 per cent of the entire number of grains and 72 per cent of the total starch in 5 minutes; in about 54 per cent of the grains and 84 per cent of the total starch in 15 minutes; in about 54 per cent of the grains and 84 per cent of the total starch in 15 minutes; in about 57 per cent of the grains and 85 per cent of the total starch in 30 minutes; in about 63 per cent of the grains and 87 per cent of the total starch in 45 minutes; in about 69 per cent of the grains and 89 per cent of the total starch in 60 minutes. (Chart D 604.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 57 per cent of the entire number of grains and 87 per cent of the total starch in 5 minutes; in about 78 per cent of the grains and 92 per cent of the total starch in 15 minutes; in about 90 per cent of the grains and 95 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes, respectively. (Chart D 605.)

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 25 per cent of the entire number of grains and 58 per cent of the total starch in 5 minutes; in about 39 per cent of the grains and 72 per cent of the total starch in 15 minutes; in about 47 per cent of the grains and 77 per

cent of the total starch in 30 minutes; in about 61 per cent of the grains and 80 per cent of the total starch in 45 minutes; in about 65 per cent of the grains and 83 per cent of the total starch in 60 minutes. (Chart D 606.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 60 per cent of the entire number of grains and 78 per cent of the total starch in 5 minutes; in about 94 per cent of the grains and 96 per cent of the total starch in 15 minutes. (Chart D 607.)

The hilum becomes as distinct as in *M. vexillaria,* but a bubble is never observed to form there. The lamellæ are not so distinct as in *M. vexillaria,* but may be observed in most of the grains, and a broad band which is not so refractive as in *M. vexillaria* is formed about the margins of the grains. Gelatinization, differing from *M. vexillaria,* usually begins at the proximal end, but occasionally at the distal, and then at the proximal end, as in *M. vexillaria.* Gelatinization progresses usually rather less smoothly than in *M. vexillaria,* and the margin is often the least resistant part as in those grains, and the most resistant part is usually the inner part of the grain just proximal to the distal margin. In those grains which begin to gelatinize as do those of *M. vexillaria,* the most resistant part is the inner part of the grain just distal to the hilum. The gelatinized grains are larger, the capsules are less thick, and they are more distorted than those of *M. vexillaria.*

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 33 per cent of the entire number of grains and 82 per cent of the total starch in 5 minutes; in about 60 per cent of the grains and 89 per cent of the total starch in 15 minutes; in about 66 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 66 per cent of the grains and 91 per cent of the total starch in 45 minutes; in about 66 per cent of the grains and 92 per cent of the total starch in 60 minutes. (Chart D 608.)

The reaction with *uranium nitrate* begins immediately. Complete gelatinization occurs in about 47 per cent of the entire number of grains and 77 per cent of the total starch in 5 minutes; in about 60 per cent of the grains and 87 per cent of the total starch in 30 minutes; in about 73 per cent of the grains and 95 per cent of the total starch in 45 minutes; in about 80 per cent of the grains and 96 per cent of the total starch in 60 minutes. (Chart D 609.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 48 per cent of the entire number of grains and 86 per cent of the total starch in 5 minutes; in about 80 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 84 per cent of the grains and 96 per cent of the total starch in 30 minutes. (Chart D 610.)

The reaction with *cobalt nitrate* begins in a few grains immediately. Complete gelatinization occurs in about 8 per cent of the entire number of grains and 48 per cent of the total starch in 5 minutes; in about 20 per cent of the grains and 56 per cent of the total starch in 15 minutes; in about 31 per cent of the grains and 62 per cent of the total starch in 30 minutes; in about 34 per cent of the grains and 64 per cent of the total starch in 45 minutes; in about 38 per cent of the grains and 70 per cent of the total starch in 60 minutes. (Chart D 611.)

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 44 per cent of the grains and 73 per cent of the total starch in 5 minutes; in about 61 per cent of the grains and 83 per cent of the total starch in 15 minutes; in about 75 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 80 per cent of the grains and 95 per cent of the total starch in 45 minutes; little if any further advance in 60 minutes. (Chart D 612.)

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 16 per cent of the entire number of grains and 52 per cent of the total starch in 5 minutes; in about 24 per cent of the grains and 64 per cent of the total starch in 15 minutes; in about 30 per cent of the grains and 68 per cent of the total starch in 30 minutes; in about 38 per cent of the grains and 70 per cent of the total starch in 45 minutes; in about 44 per cent of the grains and 72 per cent of the total starch in 60 minutes. (Chart D 613.)

The reaction with *barium chloride* begins in a few grains immediately. Complete gelatinization occurs in about 2 per cent of the entire number of grains and 6 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 11 per cent of the total starch in 15 minutes; in about 5 per cent of the grains and 15 per cent of the total starch in 30 minutes; in about 6 per cent of the grains and 18 per cent of the total starch in 45 minutes; in about 10 per cent of the grains and 22 per cent of the total starch in 60 minutes. (Chart D 614.)

The reaction with *mercuric chloride* begins immediately. Complete gelatinization occurs in about 15 per cent of the entire number of grains and 42 per cent of the total starch in 5 minutes; in about 29 per cent of the grains and 53 per cent of the total starch in 15 minutes; in about 36 per cent of the grains and 57 per cent of the total starch in 30 minutes; in about 42 per cent of the grains and 60 per cent of the total starch in 45 minutes; in about the same of both the grains and total starch in 60 minutes. (Chart D 615.)

Miltonia bleuana.

(Plate 24, fig. 141; Charts D 595 to D 615.)

Histologic Properties.

In *form* the majority of grains are simple and isolated, with the exception of a moderately large proportion that appear in aggregates (somewhat larger than in both parents), of from 2 to 14, occasionally 45, components; the larger numbers in mosaic arrangement. Compound grains of usually 2 to 3 components are more numerous than in both parents. Well-defined pressure facets are present as in both parents. The outline of the grain is frequently irregular, which is due to the same causes as noted for both parents, slightly less irregular than in *M. vexillaria* and considerably less than in *M. rœzlii.* The conspicuous forms of the isolated grains of the disaggregate type are ovoid, sometimes squared at distal end, round, pyriform, low and high triangular with rounded angles and curved sides, and ellipsoidal. The additional forms are elongated narrow ovoid, nearly round, oyster-shell- and fresh-water-mussel-shell-shaped, and grains of indefinite shape. The conspicuous forms in the isolated

grains of the aggregate type are dome-shaped with either squared, diagonal, concave or irregular distal end; polygonal; finger-shaped with concave distal end, and bell-jar-shaped with either squared or concave distal end. The conspicuous forms of aggregates are potato-shaped (a mosaic of varying numbers of components), rounded mosaic, doublets of about equal components, triplet in linear arrangement (the central component the largest), doublets and triplets consisting of 1 large component and either 1 or 2 of moderate size located usually at the distal end, rarely at the proximal. The grains are not usually flattened, about as in *M. vexillaria,* the extension laterally by secondary lamellæ being less frequent than in *M. rœzlii.* In form the grains of *M. bleuana* are closer to those of *M. vexillaria* than to *M. rœzlii.*

The *hilum* when unfissured is more distinct than in both parents; clefts appear with slightly less frequency than in *M. vexillaria,* and are considerably less numerous than in *M. rœzlii.* The hilum is often observed as either a small,lenticular or round,non-refractive to quite refractive spot, and is refractive with much more frequency than in either parent. Either a small round or an irregular cavity appears, more often than in both parents. Clefts of a similar character to those of both parents are present, being deeper but about as frequent as in *M. vexillaria,* about as deep but not quite so often observed as in *M. rœzlii.* The fissures which leave the hilum are about the same as in *M. vexillaria,* they appear with less frequency, especially the median longitudinal one, than in *M. rœzlii.* The eccentricity varies from 0.61 to 0.1, commonly 0.33 to 0.2, of the longitudinal axis, nearly the same as in *M. rœzlii* and less than in *M. vexillaria.* In the character of the hilum *M. bleuana* is closer to *M. vexillaria,* but in degree of eccentricity it is much closer to *M. rœzlii.*

The *lamellæ* are more frequently demonstrable than in both parents. The lamellæ of the primary set have, in general, the same characteristics and arrangement as noted for both parents. The border with laterally extended distal corners inclosing an ellipsoidal grain is somewhat more frequently observed than in *M. vexillaria,* but considerably less frequently than in *M. rœzlii.* There is some variation in the direction of groups of lamellæ, probably due to a shifting of the longitudinal axis, more than in *M. vexillaria,* but considerably less varied than in *M. rœzlii.* A definite secondary set of lamellæ are somewhat more frequent than in *M. vexillaria,* but much less than in *M. rœzlii.* A variation is seen in the direction of groups of lamellæ, usually only 2 as in *M. vexillaria,* but occurring with more frequency than in *M. vexillaria;* a variation in character of the groups is less frequently well marked and they are considerably less often observed than in *M. rœzlii.* In the character of the lamellæ *M. bleuana* is closer to *M. vexillaria* than to *M. rœzlii.*

The *size* of the grains varies from the small which are about 5 by 4μ, to the larger which are about 50 by 26μ, commonly about 32 by 28μ, in length and breadth. The grains of *M. bleuana* are larger than those of either parent, but are closer to *M. rœzlii* than to *M. vexillaria.*

Polariscopic Properties.

The *figure* varies from centric to quite eccentric, a smaller proportion of the eccentric than in *M. vexillaria* making the mean not quite so eccentric, a larger proportion of the quite eccentric than in *M. rœzlii,* hence the mean is more eccentric than in *M. rœzlii.* The figure is slightly less clean-cut than in *M. vexillaria,* but more than in *M. rœzlii.* The lines are generally fine though somewhat more frequently coarse than in *M. vexillaria,* but not so often as in *M. rœzlii.* The lines usually cross either at right angles or obliquely, but when coarse may occasionally be arranged in a median line with bisected ends, the former as in both parents, but the latter was never noted when the medium line is fine or as fine as sometimes found in *M. vexillaria* and more frequently in *M. rœzlii.* The lines are generally straight, often with broadening towards the margin, but may be bent and bisected, less frequently bent, but with more bisection than in both parents. More double and multiple figures than in both parents.

The *degree of polarization* is high to very high (value 88), with more of the latter than in either parent, hence making the mean higher. A variation in the same aspect of a grain is not usually present, less than in both parents.

With *selenite* the quadrants are usually sharply defined, slightly less often than in *M. vexillaria,* but found much more frequently than in both parents. They are often unequal and slightly irregular, but more frequently equal and regular than in both parents. The colors are generally pure; the impurity when present is usually indicated by a greenish tinge to both colors; the colors are more frequently pure than in both parents.

In degree of polarization, character of the figure, and appearances with selenite *M. bleuana* is closer to *M. vexillaria* than to *M. rœzlii.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains color a moderate blue-violet (value 55), which is the same as in *M. vexillaria,* but a little deeper and less violet than in *M. rœzlii;* the color deepens rapidly, becoming moderately deep to deep and more bluish in tint; there is more variation with the mean scarcely so bluish nor so deep as in *M. vexillaria,* but less variation, with the mean more bluish and deeper than in *M. rœzlii.* With 0.125 per cent Lugol's solution the grains color a light blue-violet which is at first the same tint as in *M. vexillaria* but slightly darker and more bluish than in *M. rœzlii;* the color deepens with much variation, with the mean lighter and less bluish than in *M. vexillaria;* the tint is the same but with a little more variation, with the mean slightly darker than in *M. rœzlii.* After heating in water until all the grains are gelatinized and then adding 2 per cent Lugol's solution, the gelatinized *grains* color moderately to moderately deep indigo-blue, rarely with reddish tint, a little lighter than in *M. vexillaria* and considerably lighter than in *M. rœzlii,* fewer grains with reddish tint; and the *solution* is deeper than in both parents. If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues,* which are somewhat more numerous than in both parents, color a light to moderate blue, all with reddish tint, lighter than in both parents; the *capsules,* which are much more frequently ruptured than in both parents, generally color a light to moderately deep reddish-heliotrope or amethyst, occasionally a light to deep old-rose, lighter and considerably less reddish than in *M. vexil-*

laria, nearer the tint though slightly less reddish and considerably lighter than in *M. ræzlii.* The *solution* is very deep, deeper than in both parents. In the reactions with iodine *M. bleuana* is closer to *M. vexillaria* than to *M. ræzlii.*

Aniline Reactions.

With *gentian violet* the grains color very lightly at once, and in half an hour most of them become a moderate, with rare grains a moderately deep, violet (value 47); a trifle lighter and more of a bluish violet than in *M. vexillaria*, and decidedly lighter than in *M. ræzlii.* The deeper staining of the one lamella and the lighter marginal or distal border is somewhat more noticeable than in both parents.

With *safranin* the grains color very lightly at once (lighter than in both parents), and in 30 minutes they become moderate to moderately deep (value 55), the same as in *M. vexillaria*, but considerably lighter than in *M. ræzlii.* The staining of the one lamella and regions of the grain are the same as with gentian violet.

In the reactions with aniline stains *M. bleuana* is closer to *M. vexillaria* than to *M. ræzlii.*

Temperature Reactions.

The temperature of gelatinization of the majority is at 69° to 71° C., and of all but rare resistant grains at 72° to 74° C., mean 73° C. The mesial portion of the grains of this species is gelatinized at a lower temperature than a few of the marginal lamellæ as in both parents: this central part of practically all the grains being gelatinized at 64° to 66° C., mean 65° C. The temperature of gelatinization of *M. bleuana* is lower than that of either parent, and is closer to *M. vexillaria* than to *M. ræzlii.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 45 per cent of the entire number of grains and 62 per cent of the total starch in 5 minutes; in about 72 per cent of the grains and 81 per cent of the total starch in 15 minutes; in about 90 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 95 per cent of the grains and 97 per cent of the total starch in 45 minutes; little if any further change in 60 minutes. (Chart D 595.)

The hilum is distinct as in *M. vexillaria*, and a bubble is much more frequently formed there than in either parent. The lamellæ are, usually, distinct at first, and later obscured as in *M. vexillaria*, but in some grains they are never observed as in *M. ræzlii.* A refractive space which is even broader and more refractive than in *M. vexillaria* is formed at the distal margin. Gelatinization begins usually at the distal margin as in *M. vexillaria*, but this is not so frequently followed by gelatinization of the proximal end as in that grain. The other methods observed in *M. ræzlii* are not noted here. The progress of gelatinization is the same as in *M. vexillaria* except that it is smoother and more even and the marginal starch does not appear to be so much less resistant than in the parents. The gelatinized grains are very large and even less distorted than in *M. vexillaria* and retain more of the form of the untreated grain. In this reaction *M. bleuana* shows qualitatively a closer resemblance to *M. vexillaria* than to *M. ræzlii.*

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 15 per cent of the grains and 63 per cent of the total starch in 5 minutes; in about 49 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 95 per cent of the total starch in 25 minutes; in about 80 per cent of the grains and 97 per cent of the total starch in 30 minutes; in about 97 per cent of the grains and in over 99 per cent of the total starch in 45 minutes. (Chart D 596.)

The hilum becomes as distinct as in the parents, and the lamellæ are not so distinct as in *M. vexillaria*, but more distinct than in *M. ræzlii.* Gelatinization begins at the hilum as in the parents, and a few grains are noted which are divided into several pieces by fissures as in *M. ræzlii.* The progress of gelatinization is the same as in *M. vexillaria*, except that there are more and coarser granules formed immediately about the hilum, but not so many as in *M. ræzlii*, and solution of the capsule occurs at the proximal end as often as in *M. ræzlii.* In this reaction *M. bleuana* shows qualitatively a slightly closer relationship to *M. vexillaria* than to *M. ræzlii.*

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 25 per cent of the grains and 63 per cent of the total starch in 5 minutes; in about 50 per cent of the grains and 82 per cent of the total starch in 15 minutes; in about 77 per cent of the grains and 96 per cent of the total starch in 30 minutes; in about 85 per cent of the grains and 97 per cent of the total starch in 45 minutes; in about 95 per cent of the grains and 99 per cent of the total starch in 60 minutes. (Chart D 597.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 77 per cent of the entire number of grains and 97 per cent of the total starch in 1 minute; in about 93 per cent of the grains and 99 per cent of the total starch in 2 minutes; in about 97 per cent of the grains and in over 99 per cent of the total starch in 5 minutes; in over 99 per cent of both the grains and total starch in 15 minutes. (Chart D 598.)

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 98 per cent of the entire number of grains and 99 per cent of the total starch in 1 minute; in all but the margin of rare grains and in about 99 per cent of the grains and in over 99 per cent of the total starch in 1 minute and 45 seconds; complete gelatinization (100 per cent) in 2 minutes and 15 seconds. (Chart D 599.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 98 per cent of the grains and in over 99 per cent of the total starch in 1 minute; in all but parts of very rare grains, and in over 99 per cent of both the entire number of grains and total starch in 2 minutes. (Chart D 600.)

The hilum becomes distinct as in *M. vexillaria*, and a bubble is formed there much more frequently. The lamellæ are not quite so distinct as in *M. vexillaria*, but more distinct than in *M. ræzlii.* Gelatinization begins at the hilum as in the parents, and the progress of gelatinization is much the same as in *M. vexillaria* except that the striæ are not so coarse and distinct, nor is the lamellar structure of the marginal band so obvious as in those grains. The gelatinized grains are large, thin-

walled, and as distorted as in *M. vexillaria*. In this reaction *M. bleuana* shows qualitatively a closer relationship to *M. vexillaria* than to *M. rœzlii.*

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 97 per cent of the entire number of grains and in over 99 per cent of the total starch in 1 minute; in about 98 per cent of the grains and in over 99 per cent of the total starch in 5 minutes; about the same in 10 minutes; complete gelatinization (100 per cent) occurs in all grains in 15 minutes. (Chart D 601.)

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in 54 per cent of the entire number of grains and 92 per cent of the total starch in 5 minutes; in about 95 per cent of the total starch in 10 minutes; in about 90 per cent of the grains and 98 per cent of the total starch in 15 minutes; in about 95 per cent of the grains and in over 99 per cent of the total starch in 30 minutes. (Chart D 602.)

The hilum and lamellæ are as distinct as in *M. vexillaria.* Gelatinization begins at the hilum as in both parents, and the process is the same as described under *M. vexillaria,* except that granulation is more extensive but not so extensive as in *M. rœzlii.* The gelatinized grains are large and thin-walled and somewhat more distorted than those of *M. vexillaria,* but not so much as in *M. rœzlii.* In this reaction *M. bleuana* shows qualitatively a closer relationship to *M. vexillaria* than to *M. rœzlii.*

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 87 per cent of the entire number of grains and 98 per cent of the total starch in 2 minutes; in about 95 per cent of the grains and 99 per cent of the total starch in 5 minutes. (Chart D 603.)

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in about 87 per cent of the entire number of grains and 96 per cent of the total starch in 5 minutes; in about 93 per cent of the grains and 98 per cent of the total starch in 15 minutes; in about the same percentage of the grains and 99 per cent of the total starch in 30 minutes; little if any further change in 45 and 60 minutes. (Chart D 604.)

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in about 93 per cent of the entire number of grains and 98 per cent of the total starch in 5 minutes; in more than 99 per cent of both the grains and total starch in 15 minutes. (Chart D 605.)

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 82 per cent of the entire number of grains and 95 per cent of the total starch in 5 minutes; in about 93 per cent of the grains and 99 per cent of the total starch in 15 minutes; in about 99 per cent of the grains and in over 99 per cent of the total starch in 30 minutes. (Chart D 606.)

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 78 per cent of the entire number of grains and 86 per cent of the total starch in 5 minutes; in about 95 per cent of the total starch in 10 minutes; in more than 99 per cent of both the grains and total starch in 15 minutes. (Chart D 607.)

The hilum is as distinct as in *M. vexillaria,* except that a bubble is much more often formed there. The lamellæ are not quite so distinct as in *M. vexillaria,* but more distinct than in *M. rœzlii,* and a broad band which is as refractive as in *M. vexillaria* is formed about the margins of the grains. Gelatinization as in *M. vexillaria* begins at the distal end in most grains, and in some grains the proximal end is affected immediately afterwards, but not so frequently as in *M. vexillaria,* more frequently than in *M. rœzlii.* Gelatinization progresses as in *M. vexillaria,* except that the most resistant part of the grain is more frequently at the proximal end instead of just distal to the hilum. The gelatinized grains are large, rather thick-walled, and very much distorted as in *M. vexillaria.* In this reaction *M. bleuana* shows qualitatively a closer relationship to *M. vexillaria* than to *M. rœzlii.*

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 78 per cent of the entire number of grains and 97 per cent of the total starch in 5 minutes; in about 88 per cent of the grains and 99 per cent of the total starch in 15 minutes; in about 95 per cent of the grains and in more than 99 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes, respectively. (Chart D 608.)

The reaction with *uranium nitrate* begins immediately. Complete gelatinization occurs in about 75 per cent of the entire number of grains and 95 per cent of the total starch in 5 minutes; in about 90 per cent of the grains and 99 per cent of the total starch in 15 minutes; in about 93 per cent of the grains and in over 99 per cent of the total starch in 45 minutes; in about 99 per cent of the grains and in over 99 per cent of the total starch in 60 minutes. (Chart D 609.)

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in about 94 per cent of the entire number of grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 610.)

The reaction with *cobalt nitrate* begins immediately. Complete gelatinization occurs in about 27 per cent of the grains and 67 per cent of the total starch in 5 minutes; in about 54 per cent of the grains and 81 per cent of the total starch in 15 minutes; in about 63 per cent of the grains and 89 per cent of the total starch in 30 minutes; in about 72 per cent of the grains and 90 per cent of the total starch in 45 minutes; in about 77 per cent of the grains and 99 per cent of the total starch in 60 minutes. (Chart D 611.)

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in about 84 per cent of the grains and 98 per cent of the total starch in 5 minutes; in about 95 per cent of the grains and in over 99 per cent of the total starch in 15 minutes; rare scattered grains and parts of the margin of grains remain ungelatinized; over 99 per cent of both the grains and total starch in 30, 45, and 60 minutes, respectively. (Chart D 612.)

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 60 per cent of the grains and 81 per cent of the total starch in 5 minutes; in about 72 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 85 per cent of the grains and 95 per cent of the total starch in 30

minutes; in about 88 per cent of the grains and 97 per cent of the total starch in 45 minutes; in about 93 per cent of the grains and 99 per cent of the total starch in 60 minutes. (Chart D 613.)

The reaction with *barium chloride* begins in a few grains immediately. Complete gelatinization occurs in about 0.5 per cent of the grains and 10 per cent of the total starch in 5 minutes; in about 5 per cent of the grains and 20 per cent of the total starch in 15 minutes; in about 7 per cent of the grains and 25 per cent of the total starch in 30 minutes; in about 10 per cent of the grains and 30 per cent of the total starch in 45 minutes; in about 16 per cent of the grains and 33 per cent of the total starch in 60 minutes. (Chart D 614.)

The reaction with *mercuric chloride* begins immediately. Complete gelatinization occurs in about 45 per cent of the entire number of grains and 75 per cent of the total starch in 5 minutes; in about 75 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 82 per cent of the grains and 97 per cent of the total starch in 30 minutes; in about 85 per cent of the grains and 98 per cent of the total starch in 45 minutes; in about the same percentage of both the grains and total starch in 60 minutes. (Chart D 615.)

16. CYMBIDIUM.

This genus of tropical, terrestrial orchids includes about 30 species. There are only a few varieties and hybrids. Starches from the pseudobulbs of the following parent-stocks and hybrid-stocks were studied:

44. *C. lowianum* Reichb. f. (seed parent), *C. eburneum* Lindl. (pollen parent), and *C. eburneo-lowianum* (hybrid).

The specimens were obtained from Sander and Sons, St. Albans, England.

44. Starches of Cymbidium lowianum, C. eburneum, and C. eburneo-lowianum.

Cymbidium lowianum (Seed Parent).

(Plate 24, fig. 142; Charts D 616 to D 618.)

Histologic Properties.

In *form* the grains are usually simple and isolated, with the exception of a moderately small number which appear in aggregates consisting of from 2 to 8 components. Compound grains, usually consisting of 2 components, are rarely observed. The majority of isolated grains seem to have arisen and continued to exist as such, and may be distinguished tentatively as a disaggregate type; but a moderately large proportion are separated components of aggregates, and hence may be referred to as an aggregate type. Well-marked pressure facets are present on the separated grains. The surface is usually regular. Irregularities may occur which are due chiefly to a shifting of the longitudinal axis; to a broad rounded swelling at one side that is apparently formed by a secondary set of lamellæ; to a small concave depression, probably a pressure facet, which may appear at indefinite points on the surface; to a flattening of one side of the grain; and to slight irregular prolongations at the corners of pressure facets. The conspicuous forms among the isolated grains of the disaggregate type are ovoid, ellipsoidal, pyriform, nearly round, club-shaped, and rounded triangular. The conspicuous forms among the isolated grains of the aggregate type are high and low dome-shaped with squared, pointed or diagonal distal end; bell-jar shape, polygonal, finger-shaped, and ovoid with concave distal end. Very rare large isolated grains of the disaggregate type are scattered amongst those already noted. They are usually either ovoid or pyriform in shape. The conspicuous forms among the aggregates are mosaics of from 5 to 8 components; doublets of equal and unequal components; triplets and quadruplets more often of compact but sometimes of linear arrangement. The grains are not, as a rule, flattened.

The *hilum* is usually demonstrable as a round or lenticular spot, which is usually non-refractive and but slightly refractive in a few grains. A small rounded or somewhat irregular cavity is sometimes found. Fissures are not usually present either at or proceeding from the hilum. The position of the hilum varies from centric to quite eccentric, the range of eccentricity being usually from 0.42 to 0.14, more often 0.25 to 0.15, of the longitudinal axis.

The *lamellæ* are frequently not distinct, and can be determined on a minority of the grains. When demonstrable they appear as moderately fine, circular or lenticular rings when located near the hilum, but when a short distance outward they assume the form of the grain. One lamella placed at varying distances from the hilum is more distinct than the others. A moderately refractive border in which the lamellæ are not demonstrable is occasionally observed; and a swelling located at right angle to the primary lamellæ appears to consist of a secondary set of lamellæ. On the larger grains 12 to 16, more often 14, can be counted.

The *size* of the grain varies from the small isolated disaggregate grains which are 3 by 2μ, to the larger isolated disaggregate grains which are 28 by 18μ, in length and breadth; the common size is about 20 by 14μ. The isolated aggregates vary from about 5 by 4μ to 20 by 16μ, commonly about 12 by 11μ.

Polariscopic Properties.

The *figure* varies from centric to quite eccentric, the latter in the majority of the grains. The lines in most of the grains intersect obliquely; they are fine and usually straight, often broadening towards the margin in the larger grains. Double and multiple figures are observed.

The *degree of polarization* is high (value 80). There is very little variation in the different grains, and practically no variation in a given aspect of a grain.

With *selenite* the quadrants are sharply defined; usually slightly to quite unequal in size, and more often regular in form, sometimes somewhat irregular. The *colors* are generally pure.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains color a moderate blue-violet (value 50), which deepens somewhat rapidly to a considerably darker color having a more bluish tint. With 0.125 per cent Lugol's solution the grains color a light blue-violet, which deepens somewhat rapidly to moderate, with a slightly more bluish tint. After heating in water until all the grains are

gelatinized and then adding 2 per cent Lugol's solution, most of the *grains* color a moderate blue with a reddish tint, and the *solution* colors a moderate to deep indigo-blue. If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* become a deep blue with reddish tint, and most of the *capsules* a light brick-red, and a few wine-red; the *solution* colors very deep blue. After boiling there are very few *grain-residues,* but there are many *capsules.*

Aniline Reactions.

With *gentian violet* most of the grains immediately color lightly, a few moderately. In 30 minutes they stain a moderate to moderately deep violet (value 55) with a larger proportion of the former depth.

With *safranin* the grains immediately color light to moderate. In 30 minutes most of them appear moderately stained, with a few moderately deep (value 52).

Temperature Reactions.

The majority of the grains are gelatinized at 58° to 60° C., and of all at 62° to 63° C., mean 62.5° C. The very small isolated grains and the rare quite large isolated grains are the most resistant.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 85 per cent of the entire number of grains and 90 per cent of the total starch in 2 minutes; in about 93 per cent of the grains and 95 per cent of the total starch in 3 minutes; in more than 99 per cent of the grains and total starch in 5 minutes. (Chart D 616.)

The hilum rapidly becomes very distinct, and a bubble usually is formed there which remains enlarged until the process of gelatinization has reached the hilum. The lamellæ slowly become distinct, especially in the more resistant grains, but just before they are gelatinized they become indistinct, as the starch comprising them becomes finely granular. A refractive band is formed about the margin of the more resistant grains and becomes very broad, receding as gelatinization advances from the margin inward. Gelatinization always begins at the distal end and, if there are pressure facets, at the sharp corners. This is followed by gelatinization of the marginal starch at the sides, or, rarely, at the proximal end. Gelatinization progresses much more rapidly over the surface than the interior of the grain, and there is frequently a resistant central core left when all the rest is gelatinous, but this also becomes gelatinous in time. When the hilum is reached the bubble, which is usually present, swells suddenly, and is sometimes separated into two or three bubbles, which then shrinks and disappears. The most resistant starch is either in a central core as noted, or else just distal or just proximal to the hilum. The gelatinized grains are large and somewhat distorted, but retain some of the form of the untreated grain.

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 90 per cent of the entire number of grains and 98 per cent of the total starch in 2 minutes; in over 99 per cent of both the grains and total starch in 5 minutes.

The hilum becomes distinct and the lamellæ are distinct at first but later become obscured. Gelatinization begins at the hilum, which enlarges somewhat, and the grain becomes divided by fine striæ radiating from the hilum, while a few rather small granules are formed by the extension of 2 or 3 fissures from the hilum into the surrounding starch. The hilum then continues to enlarge and the grain to swell, and the more resistant starch is pushed to the margin where it forms a smooth non-striated, non-lamellated band. This band becomes narrower and more and more nearly transparent until it and the capsule are dissolved at one point and the semi-fluid gelatinous mass in the interior flows out and is dissolved while the capsule collapses and is finally also dissolved, a few granules and shreds of capsular starch persisting for some time after the rest has been dissolved.

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 87 per cent of the entire number of grains and 98 per cent of the total starch in 5 minutes; in about 98 per cent of the grains and over 99 per cent of the total starch in 15 minutes. (Chart D 617.)

The reaction with *nitric acid* begins immediately; nearly all the grains are gelatinized in 15 seconds; all in 30 seconds, but rare resistant grains which take from 2 to 3 minutes for the completion of the reaction. The reaction is so rapid that all the details can not be satisfactorily determined. The hilum swells, and rarely fissures are observed passing from it; during the process an invagination occurs at one or more points. The gelatinized grains are much swollen and distorted so that they do not resemble the form of the untreated grain.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization (100 per cent) of all the grains occurs in 15 seconds.

The reaction with *hydrochloric acid* begins immediately and gelatinization is practically instantaneous; complete gelatinization of all grains occurs in 10 seconds or earlier. The reaction is so rapid that the minute steps of the process can not be studied. The gelatinized grains are much swollen and considerably distorted, the latter markedly so at the distal margin; the capsule at the proximal end and sides is thicker and often quite refractive. This capsule gradually becomes less distinct until it is dissolved in all but rare grains in 30 minutes.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization of all the grains occurs in 10 seconds. Since gelatinization is complete when the slide is placed under observation, the process may be instantaneous. The reaction is so rapid that the details can not be satisfactorily demonstrated. The gelatinized grains are much swollen and considerably distorted at the distal margin.

The reaction with *potassium iodide* begins immediately, all but a few resistant grains being gelatinized in 15 seconds. The reaction is completed in 30 seconds, with the exception of rare scattered separated grains, which are gelatinized in 1 minute. The reaction is so rapid that no details can be made out. The gelatinized grains are swollen and considerably distorted, so that they do not resemble the shape of the untreated grain.

The reaction with *potassium sulphocyanate* begins immediately; nearly all the grains are gelatinized in 5 seconds, all in 10 seconds. The reaction is so rapid, that no details of the process can be determined. The gela-

tinized grains are much swollen and distorted, so that they do not resemble the form of the untreated grain.

The reaction with *potassium sulphide* is instantaneous; no details of the reaction can be determined. The gelatinized grains are much swollen and distorted, so that they do not resemble the untreated grain.

The reaction with *sodium hydroxide* begins immediately; all the grains are gelatinized in 10 seconds. The reaction is so rapid that the minute steps can not be studied. The gelatinized grains are much swollen and distorted so that they usually do not resemble the form of the untreated grains.

The reaction with *sodium sulphide* begins immediately; many are gelatinized in 5 seconds; all in 10 seconds. The reaction is so very rapid that the minute steps of the process can not be determined. The gelatinized grains are swollen and much distorted so that they do not resemble the form of the untreated grain.

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 88 per cent of the entire number of grains and 89 per cent of the total starch in 1 minute; in about 98 per cent of the grains and 99 per cent of the total starch in 2 minutes.

The hilum is very distinct and a bubble is usually formed there. The lamellæ are at first distinct, but later become obscured. A narrow, refractive band is formed, quickly, about the margin of the grains before gelatinization begins and remains there as gelatinization proceeds. Gelatinization begins at the distal margin, and is preceded by a pitted appearance of the starch at the distal end. From here it proceeds rapidly and smoothly toward the proximal end until the hilum is reached. There the bubble enlarges, then shrinks and disappears, and the hilum in enlarging splits the remaining ungelatinized material at the proximal end into 2 or 3 pieces which rapidly gelatinize. The last to gelatinize are the pieces at the sides. The gelatinized grains are large and much distorted at the distal end but not at the proximal end, and so they retain some of the form of the untreated grain.

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in all but rare grains in 15 seconds and in 100 per cent of both the grains and total starch in 30 seconds.

The reaction with *uranium nitrate* begins immediately. Complete gelatinization occurs in about 80 per cent of the entire number of grains and 96 per cent of the total starch in 30 seconds; in 100 per cent of both the grains and total starch in 1 minute.

The reaction with *strontium nitrate* begins immediately. Complete gelatinization occurs in all but a few grains in 15 seconds, all in 30 seconds.

The reaction with *cobalt nitrate* begins immediately. Complete gelatinization occurs in over 99 per cent of both the grains and total starch in 45 seconds, and in 100 per cent of both the grains and total starch in 2 minutes.

The reaction with *copper nitrate* begins immediatly. Complete gelatinization occurs in nearly all the grains in 15 seconds, and in all grains (100 per cent of both the grains and total starch) in 30 seconds.

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 95 per cent of the entire number of grains and 98 per cent of the total starch in 30 seconds; and in all but rare smaller grains and parts of the grains and margin of larger grains are gelatinized—over 99 per cent of both the grains and total starch in 1 minute.

The reaction with *barium chloride* begins immediately. Complete gelatinization occurs in about 85 per cent of the entire number of grains and 97 per cent of the total starch in 5 minutes; in about 93 per cent of the grains and 99 per cent of the total starch in 15 minutes; in about 95 per cent of the grains and 99 per cent of the total starch in 30 minutes; in about 97 per cent of the grains and 99 per cent of the total starch in 45 minutes; in about 98 per cent of the grains and over 99 per cent of the total starch in 60 minutes. (Chart D 618.)

The hilum becomes distinct, and the lamellæ are visible but not distinct. Gelatinization begins at the hilum, which enlarges somewhat, and large branching fissures extend from the hilum to the distal end, or to the margin, if the distal end can not be determined on account of the centric position of the hilum, and these widen as the hilum swells, and divide much of the grain into coarse granules which are soon gelatinized, the rest of the grain is pushed to the margin and these form a lamellated unstriated band which becomes thinner and more and more nearly transparent until only the capsule remains.

The gelatinized grains are large and thin-walled and somewhat distorted, but show some of the form of the untreated grain.

The reaction with *mercuric chloride* begins immediately. Complete gelatinization occurs in about 98 per cent of the entire number of grains and over 99 per cent of the total starch in 1 minute; complete gelatinization in all but very rare grains in 1 minute and 30 seconds; and in all grains in 2 minutes.

The hilum becomes distinct, and the lamellæ are at first not distinct, but later become moderately distinct. Gelatinization begins at the hilum, which enlarges, and the starch immediately surrounding the hilum, in the meantime, is divided into coarse granules by irregular fissures proceeding from the hilum. As the hilum enlarges, the grain enlarges also, and the more resistant starch is pushed to the margin where it forms a lamellated finely striated band, around the inner border of which are the granules whose formation has been described. This marginal band becomes gradually thinner and more nearly transparent as the grain increases in size until finally the thin capsule only is left, and the granules gelatinize somewhat more slowly but finally also disappear. The gelatinized grains are large and somewhat distorted, but retain some resemblance to the form of the untreated grain.

Cymbidium eburneum (Pollen Parent).

(Plate 24, fig. 143; Charts D 616 to D 618.)

Histologic Properties.

In *form* the grains are usually simple and isolated, with the exception of a moderately small number which appear in aggregates of from 2 to 10 components. Compound grains of 2 components are rarely observed. The majority of isolated grains are the separated components of aggregates, and are somewhat greater in number than in *C. lowianum*. A moderately large proportion of the grains of the isolated disaggregate type are present, but

somewhat less than in *C. lowianum.* Well-marked pressure facets are present and are more numerous on the separated grains than in *C. lowianum.* The surface of the grains of the isolated disaggregate type is usually regular, more often than in *C. lowianum,* but the same irregularities were observed with the exception of the broad rounded swelling at one side which probably consists of a secondary set of lamellæ. The conspicuous forms among the grains of the isolated disaggregate types are nearly round, round, ovoid, ellipsoidal, and pyriform. The conspicuous forms of the separated grains are low and high dome-shaped, usually with either a squared or pointed distal end, bell-jar-shaped, polygonal and ovoid with concave distal end. In addition a few much larger grains of the isolated disaggregate type are scattered among those already noted, and they are more numerous and more varied in form than in *C. lowianum;* they have various shapes such as broad and low triangular ellipsoidal, nearly round and high triangular. The conspicuous forms of the aggregates are the same as in *C. lowianum,* but the compactly arranged triplets and quadruplets are more common; the components of doublets are more often of equal size, and the mosaics of from 5 to 10 components are more rounded in form, than in *C. lowianum.* The grains are not usually flattened.

The *hilum* is usually demonstrable and may appear as a small, round or lenticular, non-refractive or slightly refractive spot, as in *C. lowianum;* but generally either a cavity or a cleft is found at the hilum, and much more frequently than in *C. lowianum.* The cavity varies from small to moderately large and rounded. The hilum varies from centric to moderately eccentric. The range of eccentricity is usually from 0.42 to 0.25, more often from 0.42 to 0.33, of the longitudinal axis, less than in *C. lowianum.* The fissures at the hilum are generally arranged as follows: 1 short, transverse or diagonal; a group forming a stellate figure, or one transverse that is intersected by a diagonal longitudinal to form a cruciate figure. The longitudinal fissures sometimes intersect the hilum; also sometimes one of a pair of oblique fissures; and also the middle one of a group that extends both distalward and proximalward; but more frequently the fissures emerge from the hilum and are directed distalward. In dome-shaped grains there are 2 to 3 fissures proceeding from the hilum to the corners of the pressure facets at the distal margin, depending upon whether a squared or pointed distal end is present, etc.

The *lamellæ* are not usually demonstrable, much less often than in *C. lowianum.* When apparent they are found to be of the same character and arrangement as in *C. lowianum* with the exception that no evidence was noted of a secondary set placed at right angle to the primary set. Since the number can not be determined throughout the whole grain, the entire number is problematical, but on the larger isolated grains in which most of them are demonstrable, 8 to 10 may be counted, probably less than in *C. lowianum.*

The *size* of the grains varies usually from the small isolated disaggregate type, 3 by 2μ, to the larger grains of this type which are 17 by 12μ, in length and breadth. The common size is about 12 by 10μ in length and breadth. The isolated grains of the aggregate type vary from the smaller which are 4 by 3μ, to the larger which are 17 by 12μ, commonly 8 by 8μ, in length and breadth. The grains are, on the whole, smaller than in *C. lowianum.*

POLARISCOPIC PROPERTIES.

The *figure* varies from centric to rarely quite eccentric, and is slightly eccentric in the majority of the grains. It is not so eccentric as in *C. lowianum.* The characters and the arrangements of the lines are about the same as in *C. lowianum.* Double and multiple figures are observed in about the same proportion as in *C. lowianum.*

The *degree of polarization* is high (value 75), but there is a greater variation among the different grains, some being moderately high, thus making the mean somewhat lower than in *C. lowianum.*

With *selenite* the quadrants are sharply defined as in *C. lowianum.* They are usually less unequal in size than in *C. lowianum,* but of about the same degree of regularity. The colors are pure in most of the grains, but the yellow is less often pure than in *C. lowianum.*

IODINE REACTIONS.

With 0.25 per cent Lugol's solution the grains color a moderate reddish-violet (value 45), slightly lighter and considerably more reddish than in *C. lowianum.* They deepen about as rapidly, but do not reach quite so great a depth, and they remain more reddish than in *C. lowianum.* With 0.125 per cent Lugol's solution, the grains color a light reddish-violet which deepens somewhat rapidly to a moderate reddish-violet, the color both immediately and later being slightly lighter and considerably redder than in *C. lowianum.* After heating in water until all the grains are gelatinized and then adding a 2 per cent Lugol's solution, most of the *grains* become a deep dull blue, and a few of a moderate blue, but all with reddish tint; the mean coloration is deeper with less of a reddish tint than in *C. lowianum.* The *solution* is a deep purplish-blue, deeper and more reddish than in *C. lowianum.* If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution, most of the *grain-residues* color a moderate blue, a few a deep blue, all with reddish tint; most of the *capsules* color a deep reddish-heliotrope, a few being wine-red. The *grain-residues* are lighter and far more numerous, the *capsules* are colored deeper but are much less reddish in tint, and the *solution* is slightly lighter in color than in *C. lowianum.*

ANILINE REACTIONS.

With *gentian violet* the grains immediately color lightly to moderate, a larger number of the latter than in *C. lowianum,* so that the mean reaction is somewhat deeper. In 30 minutes they vary from light to moderately deep, the majority being moderate (value 57). There is greater variation among the grains, but more of the moderately deep, and hence the mean reaction is slightly deeper than in *C. lowianum.*

With *safranin* the grains immediately color light to moderate, with a larger number of the former color; the mean is slightly deeper than in *C. lowianum.* In 30 minutes the majority are colored moderately, a minority moderately deeply colored (value 55), a larger number of the latter than in *C. lowianum,* and hence the mean coloration is slightly deeper.

Temperature Reactions.

The temperature of gelatinization of the majority of the grains is 58° to 59.5° C., and of all but rare resistant grains is 65° to 66.5° C., mean 65.75° C. The most resistant grains are the very small and the rare scattered quite large isolated grains of the disaggregate type. A larger number of both are present than in *C. lowianum.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 90 per cent of the entire number of grains and 92 per cent of the total starch in 2 minutes; in about 95 per cent of the grains and 97 per cent of the total starch in 3 minutes; in over 99 per cent of the grains and total starch in 5 minutes. (Chart D 616.)

The hilum becomes very distinct, and a bubble is rarely formed there. The lamellæ become distinct in the more resistant grains, but just before they are gelatinized they become indistinct as the starch composing them becomes finely granular. A refractive band is formed about the margin of the more resistant grains and recedes inward as gelatinization progresses. Gelatinization begins always at the distal margin, and occasionally this is followed immediately by gelatinization of the proximal margin. Gelatinization progresses from these initial points as in *C. lowianum*, the most resistant starch, however, being always just distal to the hilum and never in a central core. The gelatinized grains are moderately large and not much distorted, and retain more of the forms of the untreated grains than do those of *C. lowianum.*

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 77 per cent of the entire number of grains and 97 per cent of the total starch in 2 minutes; in about 96 per cent of the grains and 99 per cent of the total starch in 5 minutes.

The hilum is not so distinct as in *C. lowianum* and the lamellæ are usually not visible. Gelatinization as in *C. lowianum* begins at the hilum and is the same as in those grains except that no granules are formed of the starch near the hilum and the grain is at no time observed to be covered by fine striæ. Dissolution of the capsule takes place somewhat more rapidly than in *C. lowianum.*

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 69 per cent of the grains and 95 per cent of the total starch in 5 minutes; in about 94 per cent of the grains and 99 per cent of the total starch in 15 minutes; in about 97 per cent of the grains and over 99 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes, respectively. (Chart D 617.)

The reaction with *nitric acid* begins immediately; nearly all the grains are gelatinizd in 15 seconds; all but rare resistant ones in 45 seconds; these may resist the reaction for from 3 to 6 minutes.

The margin is the most resistant part of the grains, especially the margin in the separated components of aggregates which are much more numerous than in *C. lowianum.* The reaction is qualitatively about the same as in *C. lowianum,* the process is so rapid that no minute differences in detail can be detected, with the exception that invagination does not usually accompany the reaction. The gelatinized grains are swollen but not usually distorted, much less than in *C. lowianum.* The wall of the gelatinized grain is thicker than in *C. lowianum.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in all but rare grains, and over 99 per cent of both grains and total starch in 15 seconds; in all grains (100 per cent) in 25 seconds.

The reaction with *hydrochloric acid* begins immediately, all but a few grains are completely gelatinized in 10 seconds, all in 15 seconds. The reaction is so rapid that the minute steps can not be studied as in *C. lowianum.*

The gelatinized grains are swollen but many are not distorted and others show but slight distortion, less distortion than in *C. lowianum.* The capsule is thicker and more refractive as well as much more resistant than in *C. lowianum* since it remains undissolved in many grains in 45 minutes, but in 60 minutes the capsule of all but rare grains passes into solution.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization of all grains occurs in 10 seconds and probably sooner since the reaction is completed by the time the coverslip is adjusted and the slide under observation. The details of the reaction can not be satisfactorily stated as noted in *C. lowianum.*

The gelatinized grains are much swollen as in *C. lowianum,* but distortion is much less frequent and the capsule is considerably thicker.

The reaction with *potassium iodide* begins immediately; nearly all are gelatinized in 15 seconds; all but rare resistant grains in 30 seconds, these usually in 45 seconds, rarely in 1 minute. The reaction is too rapid, as in *C. lowianum,* to make detailed observations. The gelatinized grains are swollen, but very little distorted, much less than in *C. lowianum;* they, unlike this species, do resemble the shape of the untreated grain. The capsule is thicker than in *C. lowianum.*

The reaction with *potassium sulphocyanate* begins immediately; nearly all the grains are gelatinized in 5 seconds, all in 10 seconds. The reaction is qualitatively about the same as in *C. lowianum,* but the process is so rapid that the details can not be satisfactorily determined.

The gelatinized grains are much swollen, but only slightly distorted; the distortion is less and the wall of the grain thicker than in *C. lowianum.* The gelatinized grains usually resemble the form of the untreated grain, more than in *C. lowianum.*

The reaction with *potassium sulphide* is instantaneous; no details can be determined as in *C. lowianum.* The gelatinized grains are much swollen and distorted, though somewhat less distorted than in *C. lowianum.*

The reaction with *sodium hydroxide* begins immediately; all the grains are gelatinized but a few resistant in 10 seconds; all in 15 seconds. The reaction is so rapid, that the minute steps can not be studied, as is the case with *C. lowianum.*

The gelatinized grains are much swollen, and usually but slightly distorted; they are less distorted and have a thicker wall than in *C. lowianum.* The gelatinized grains usually bear some resemblance to the form of the untreated grains, much closer than *C. lowianum.*

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 98 per cent of the entire number of grains and over 99 per cent of the total starch in 1 minute; rare parts of grains remain; over 99 per cent of both the grains and total starch in 2 minutes; complete gelatinization occurs in 3 minutes.

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 87 per cent of the entire number of grains and 88 per cent of the total starch in 1 minute; in over 99 per cent of the grains and total starch in 2 minutes.

The hilum, as in *C. lowianum*, is very distinct and a bubble is usually formed there The lamellæ are not so distinct as in *C. lowianum* and later are obscured entirely as in those grains. A narrow refractive band is formed quickly about the margin of the grains before gelatinization begins and remains there as gelatinization proceeds. Gelatinization (unlike *C. lowianum*) begins usually at several points on the margin at once, and occasionally at the distal margin as in *C. lowianum*. The progress of gelatinization from this beginning is essentially the same as that in the grains of *C. lowianum* except that it proceeds so rapidly that the starch of the interior of the grain is torn into several large fragments, which fly apart and then are gelatinized. The gelatinized grains are large and more distorted, and retain less of the form of the untreated grain than do those of *C. lowianum*.

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 95 per cent of the entire number of grains and 98 per cent of the total starch in 30 seconds, and in 100 per cent of both the grains and total starch in 1 minute and 15 seconds.

The reaction with *uranium nitrate* begins immediately. Complete gelatinization occurs in about 84 per cent of the entire number of grains and 97 per cent of the total starch in 30 seconds; in 100 per cent of both the grains and total starch in 1 minute.

The reaction with *strontium nitrate* begins immediately. Most of the grains are gelatinized in 15 seconds, and over 99 per cent of both the grains and total starch in 30 seconds.

The reaction with *cobalt nitrate* begins immediately. Complete gelatinization occurs in about 97 per cent of the grains and 98 per cent of the total starch in 30 seconds; in about 99 per cent of the grains and over 99 per cent of the total starch in 1 minute; in 100 per cent of both the grains and total starch in 2 minutes.

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in all but rare grains in 30 seconds, and in all (100 per cent) of both the grains and total starch in 45 seconds.

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 97 per cent of the entire number of grains and 99 per cent of the total starch in 1 minute; in about 99 per cent of the grains and over 99 per cent of the total starch in 2 minutes; all but very rare smaller grains and parts of the margin of rare grains gelatinized; over 99 per cent of both the grains and total starch in 5 minutes.

The reaction with *barium chloride* begins immediately. Complete gelatinization occurs in about 80 per cent of the entire number of grains and 96 per cent of the total starch in 5 minutes; in about 94 per cent of the grains and 99 per cent of the total starch in 15 minutes; in about 97 per cent of the grains and over 99 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes, respectively. (Chart D 618.)

The hilum as in *C. lowianum* is distinct, but the lamellæ are not visible. Gelatinization, as in *C. lowianum*, begins at the hilum and the progress is the same as in those grains except that fissuration is not so deep nor so extensive, and the marginal band is not lamellated. The gelatinized grains are not so large nor so distorted as in *C. lowianum*.

The reaction with *mercuric chloride* begins immediately. Complete gelatinization occurs in about 92 per cent of the grains and 98 per cent of the total starch in 1 minute; in about 97 per cent of the grains and over 99 per cent of the total starch in 2 minutes; in all the grains (100 per cent) in 5 minutes.

The hilum and lamellæ are moderately distinct, but not so distinct as in *C. lowianum*. Gelatinization as in *C. lowianum* begins at the hilum and progresses in the same way as described under *C. lowianum*, except that the starch immediately surrounding the hilum is not always divided into granules, and when it is the granules are not so coarse, not so numerous, while the marginal border does not show a lamellated structure. The gelatinized grains are large and slightly less distorted than in *C. lowianum*, but retain the same amount of resemblance to the form of the untreated grain.

Cymbidium eburneo-lowianum (Hybrid).

(Plate 24, fig. 144; Charts D 616 to D 618.)

Histologic Properties.

In *form* the grains are usually simple and isolated, with the exception of a few (a smaller number than in either parent), which appear in aggregates of from 2 to 8 components. Compound grains, consisting of 2 components, are rarely observed. The number of grains of the isolated disaggregate type and of the aggregate type is about the same, but there are less of the former than in *C. lowianum*, but more than in *C. eburneum*, and considerably more of the latter than in *C. lowianum*, but somewhat less than in *C. eburneum*. Well-marked pressure facets are more numerous than in *C. lowianum*, but somewhat less than in *C. eburneum*. The surface of the grain is usually regular, and such irregularities as may occur are due to the same causes as noted for both parents. There is slightly less irregularity than in *C. lowianum*, but somewhat more than in *C. eburneum*. The conspicuous forms among the isolated grains of the disaggregate type are nearly round, pyriform, round, ovoid, ellipsoidal, and rounded triangular. These grains are somewhat more broadened, as in *C. lowianum*, but of about the same size; and they are of much the same proportions, but considerably larger than most of the grains of *C. eburneum*. The conspicuous forms of the grains of the isolated aggregate type are both low and high dome-shaped (with more of the former than in *C. lowianum*, but about the same as in *C. eburneum*), with squared, pointed or diagonal distal end, bell-jar-shaped, polygonal, and ovoid with concave distal end. Very rare large isolated grains of the disaggregate type are scattered among those already noted. These grains are usually pyriform, ovoid, or low triangular, and they are slightly more numerous

than in *C. lowianum,* but less numerous than in *C. eburneum.* The aggregates are of similar character to those noted for both parents, but the components of doublets are more often of equal size than in *C. lowianum* and about the same as in *C. eburneum;* and the mosaics of from 5 to 8 components are more often of rounded form than in *C. lowianum,* but not so frequently as in *C. eburneum.* The grains are not usually flattened as in the parents. In form the grains of *C. eburneo-lowianum* are slightly closer to *C. lowianum* than *C. eburneum,* but there are only slight differences between the parents and the hybrid.

The *hilum* is not very distinct, and frequently is undemonstrable, but much more often than in the parents. It appears as a small, round or lenticular, nonrefractive spot. A small cavity is observed at the hilum with slightly greater frequency than *C. lowianum,* but much less often than in *C. eburneum.* Fissures at and proceeding from the hilum are sometimes present, slightly more often than in *C. lowianum,* and much less often than in *C. eburneum.* These fissures have about the same arrangement as that noted for *C. eburneum.* The position of the hilum varies from centric to quite eccentric. The range of eccentricity is usually from 0.44 to 0.25, commonly about 0.33, of the longitudinal axis, about the same as in *C. eburneum.* Since the hilum is less frequently demonstrable than in either parent, it is possible that it was not different in grains in which the eccentricity was greater than measurements given. In the character of the hilum, *C. eburneo-lowianum* is slightly closer to *C. lowianum* but in the range of eccentricity it is closer to *C. eburneum.*

The *lamellæ* are generally indistinct, and less often demonstrable than in *C. lowianum* but somewhat more frequently seen than in *C. eburneum.* When demonstrable they have the same general structure and arrangement as in both parents; a secondary set of lamellæ placed at right angles to the primary set was observed as in *C. lowianum,* this set not being noted in *C. eburneum.* On the larger grains 12 to 16, commonly 14, may be counted. In the character and number of the lamellæ *C. eburneo-lowianum* is slightly closer to *C. lowianum* than to *C. eburneum.*

The *size* varies from the smaller isolated grains of the disaggregate type which are 3 by 2μ, to the larger isolated grains of the same type which are 28 by 20μ, in length and breadth. The common size is about 20 by 18μ. The isolated grains of the aggregate type vary from 5 by 4μ to 16 by 14μ in length and breadth; the common size being 10 by 9μ in length and breadth. There are many more of these smaller grains of this type than in *C. lowianum,* hence the mean size is less than in this species, although nearer to this species than to *C. eburneum.* In size the grains of *C. eburneo-lowianum* are closer to *C. lowianum* but in proportion of length to breadth they are closer to *C. eburneum.*

Polariscopic Properties.

The *figure* varies from centric to quite eccentric as in both parents, but those of the quite eccentric type are less frequent than in *C. lowianum,* but considerably more numerous than in *C. eburneum.* The character and the arrangement of the lines are about the same as in both parents. Double and multiple figures are observed, but they are somewhat less numerous than in the parents.

The *degree of polarization* is high (value 80). It is the same as in *C. lowianum,* and higher than in *C. eburneum.* The grains vary somewhat from high to very high, and there is more variation in the different grains than in either parent.

With *selenite* the quadrants are sharply defined, as in both parents. They are generally somewhat less unequal in size than in *C. lowianum;* but nearer this species than *C. eburneum.* They are more often regular though they may be somewhat irregular, as in both parents. The colors are generally pure, the same as in *C. lowianum,* the yellow more often pure than in *C. eburneum.*

In degree of polarization, character of the figure, and appearances with selenite the grains of *C. eburneo-lowianum* are closer to *C. lowianum* than to *C. eburneum.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains color a moderate violet (value 50) with a little more of a reddish tint than in *C. lowianum,* but nearer the color of this species than in *C. eburneum.* The color deepens, becoming more bluish, and changing with somewhat greater rapidity than in the parents. With 0.125 per cent Lugol's solution the grains color a light violet of the same depth but with more of a reddish tint than in *C. lowianum,* and a little lighter and less reddish than in *C. eburneum.* The color deepens to moderately deep, reaching a greater depth with somewhat more rapidity than in the parents. After heating in water until all the grains are gelatinized and then adding 2 per cent Lugol's solution the *grains* become a moderately deep, bright indigo-blue, many with a tint of red. The color is deeper and less reddish than in *C. lowianum,* and lighter and less reddish than in *C. eburneum.* The *solution* is colored deeper than in *C. lowianum,* and about as deep as in *C. eburneum,* but nearer the tint of *C. lowianum.* If the preparation is boiled for 2 minutes and then treated with 2 per cent Lugol's solution the *grain-residues* color a light to a moderate blue with reddish tint, lighter than in the parents. They are far more numerous than in *C. lowianum,* but about as in *C. eburneum.* Most of the *capsules* color a deep old-rose to deep reddish-heliotrope, and a few wine-red; they are colored deeper but not quite so red as in *C. lowianum,* but decidedly more reddish than in *C. eburneum.* A greater variation in tint exists than in either parent. The solution is colored about the same as in *C. lowianum,* but slightly deeper than in *C. eburneum.* In the reaction with iodine *C. eburneo-lowianum* shows a closer relationship to *C. lowianum* than to *C. eburneum.*

Aniline Reactions.

With *gentian violet* most of the grains color lightly immediately, a few moderately. In 30 minutes they are light to moderately deep (value 55), the majority being moderate. There is a greater variation but the mean is the same as in *C. lowianum,* while the variation is about the same, but the mean color slightly lighter than in *C. eburneum.*

With *safranin* the grains immediately color light to moderate, mostly the former, the reaction being the same as in *C. lowianum,* but slightly lighter than in *C. ebur-*

neum. In half an hour most of the grains are colored moderately (value 52), and a few moderately deep, as in *C. lowianum,* but slightly lighter than *C. eburneum.*

In the reaction with aniline stains *C. eburneo-lowianum* shows a closer relationship to *C. lowianum* than to *C. eburneum.*

Temperature Reactions.

The majority of the grains are gelatinized at 61° to 63° C., and all excepting rare resistant grains at 67° to 68° C., mean 67.5° C. The most resistant grains are those of the small isolated disaggregate type. The temperature of gelatinization of *C. eburneo-lowianum* is higher than in either parent, but is closer to that of *C. eburneum* than to *C. lowianum.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 80 per cent of the entire number of grains and 85 per cent of the total starch in 2 minutes; in about 84 per cent of the grains and 90 per cent of the total starch in 3 minutes; in about 98 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 616.)

The hilum becomes distinct and a bubble is often formed there, more often than in *C. eburneum,* but less often than in *C. lowianum.* The lamellæ become distinct in most of the grains, especially the more resistant ones. A refractive band is formed about the margin of the more resistant grains as noted in both parents. Gelatinization begins at the distal margin, sometimes followed immediately by the swelling of the hilum and of the proximal end. Gelatinization follows the same progress as described under *C. lowianum,* which process it resembles closely. The gelatinized grains are large and somewhat distorted, resembling those of *C. lowianum.* In this reaction *C. eburneo-lowianum* shows qualitatively a closer relationship to *C. lowianum* than to *C. eburneum.*

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 50 per cent of the entire number of grains and 65 per cent of the total starch in 2 minutes; in about 66 per cent of the grains and 95 per cent of the total starch in 5 minutes; complete gelatinization 100 per cent of both the grains and total starch in 15 minutes.

The hilum and lamellæ are distinct as in *C. lowianum,* and gelatinization begins at the hilum as in both parents. The process is the same as that described under *C. lowianum,* except that the granules formed of the material around the hilum are larger and more numerous than in *C. lowianum.*

In this reaction *C. eburneo-lowianum* shows, qualitatively, a closer relationship to *C. lowianum* than to *C. eburneum.*

The reaction with *pyrogallic acid* begins immediately. Complete gelatinization occurs in about 57 per cent of the entire number of grains and 83 per cent of the total starch in 5 minutes; in about 81 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 91 per cent of the grains and 98 per cent of the total starch in 30 minutes; in about 96 per cent of the grains and 99 per cent of the total starch in 45 minutes; about the same in 60 minutes. (Chart D 617.)

The reaction with *nitric acid* begins immediately; the majority are gelatinized in 30 seconds; nearly all in 45 seconds; all but a part of the margin of the larger grains and a few of the smaller grains in 1 minute; all but rare resistant grains in 2 minutes; the reaction is usually complete in these in 3 to 5 minutes.

The reaction is qualitatively about the same as in both parents, the reaction being so rapid that minute differences are not satisfactorily studied; fissures, however, leaving the hilum are observed with much more frequency than in both parents, and invagination during the progress was not noted; this occurred with great frequency in *C. lowianum,* but was not observed in *C. eburneum.* The gelatinized grains are swollen, and often somewhat distorted, less than in *C. lowianum,* but considerably more than in *C. eburneum.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in over 99 per cent of the grains in 15 seconds, and in 100 per cent in 25 seconds.

The reaction with *hydrochloric acid* begins immediately and is practically instantaneous; complete gelatinization occurs in all of the grains in 10 seconds. The reaction is so rapid that the minute steps can not be satisfactorily studied, as noted for both parents. The gelatinized grains are much swollen and distorted, while closely resembling *C. lowianum* in both distortion and refractivity, yet the former is somewhat greater and the latter somewhat less; while the distortion is considerably greater and the refraction less than in *C. eburneum.* The capsule reacts as in both parents and passes into solution with the exception of rare grains in 30 seconds.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in all but rare grains in 15 seconds; in all the grains in 1 minute and 15 seconds.

The reaction with *potassium iodide* begins immediately. Complete gelatinization occurs in about 89 per cent of the entire number of grains and 97 per cent of the total starch in 1 minute; in about 97 per cent of the grains and 99 per cent of the total starch in 2 minutes; in about 99 per cent of the grains and in over 99 per cent of the total starch in 3 minutes.

The reaction is slower than in the parents so that some of the details can be observed. The hilum swells and definite longitudinal fissures proceed towards the distal margin of elongated and separated grains, and fine radiating fissures from many points of the hilum of rounded grains.

The mesial portion of the grain is quickly gelatinized, but a few marginal lamellæ are much more resistant; these become sharply defined and striated but are disorganized without breaking into refractive granules. The gelatinized grains are slightly to quite distorted, considerably less than in *C. lowianum,* but somewhat more than in *C. eburneum.* The capsule is slightly thicker than in *C. lowianum,* but not quite so thick as in *C. eburneum.* They bear a closer resemblance to the untreated grain than in *C. lowianum,* but not so close as in *C. eburneum.*

The reaction with *potassium sulphocyanate* begins immediately. Complete gelatinization occurs in about 85 per cent of the entire number of grains and 96 per cent of the total starch in half a minute; in about 94 per cent of the grains and 98 per cent of the total starch in 1

minute; in all but very rare grains more than 99 per cent in 2 minutes. The reaction is qualitatively about the same as in the parents; the reaction in all three being so rapid that minute differences can not be determined. The gelatinized grains are swollen and considerably distorted, somewhat less than in *C. lowianum*, but more than in *C. eburneum*. They do not usually resemble the shape of the untreated grain, about as in *C. lowianum*, less frequently than in *C. eburneum*.

The reaction with *potassium sulphide* begins immediately. Complete gelatinization occurs in all but a few grains in 15 seconds, and in all the grains in 1 minute and 15 seconds.

The reaction with *sodium hydroxide* begins immediately. Complete gelatinization occurs in all but rare grains in 30 seconds, and in all grains in 1 minute.

The reaction is so rapid that the minute steps can not be studied, as in both parents. The gelatinized grains are much swollen and distorted, about as much distorted as in *C. lowianum;* more than in *C. eburneum;* the wall is slightly thicker than in *C. lowianum*, but thinner than in *C. eburneum*. The gelatinized grains do not usually resemble the untreated grains, as in *C. lowianum;* less resemblance is seen than in *C. eburneum*.

The reaction with *sodium sulphide* begins immediately. Complete gelatinization occurs in about 92 per cent of the entire number of grains and 99 per cent of the total starch in 1 minute; in about 98 per cent of the grains and over 99 per cent of the total starch in 2 minutes; in over 99 per cent of both the grains and total starch in 5 minutes.

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 80 per cent of the entire number of grains and 81 per cent of the total starch in 1 minute; in about 94 per cent of the grains and 95 per cent of the total starch in 2 minutes; in about 98 per cent of the grains and 99 per cent of the total starch in 3 minutes.

The hilum, as in the parents, is very distinct, and a small bubble is formed there. The lamellæ are, at first, as distinct as in *C. lowianum*, and later become obscured. A narrow, refractive band is formed quickly about the margin of the grains and remains there as gelatinization proceeds. Gelatinization as in *C. lowianum* begins at the distal margin in most of the grains, and in some at various points on the margin as in *C. eburneum*. The progress of gelatinization in most of the grains is the same as that described under *C. lowianum*, and in a few the same as under *C. eburneum*. The gelatinized grains are large and much distorted and retain less of the form of the untreated grain than those of *C. lowianum*, but more than those of *C. eburneum*. In this reaction *C. eburneo-lowianum* shows qualitatively a closer relationship to *C. lowianum* than to *C. eburneum*.

The reaction with *calcium nitrate* begins immediately. Complete gelatinization occurs in about 66 per cent of the entire number of grains and 80 per cent of the total starch in 30 seconds; in about 84 per cent of the grains and 95 per cent of the total starch in 1 minute; in about 95 per cent of the grains and 99 per cent of the total starch in 2 minutes.

The reaction with *uranium nitrate* begins immediately. Complete gelatinization occurs in about 71 per cent of the entire number of grains and 90 per cent of the total starch in 1 minute; in about 86 per cent of the grains and 95 per cent of the total starch in 2 minutes; in about 97 per cent of the grains and in over 99 per cent of the total starch in 5 minutes.

The reaction with *strontium nitrate* begins immediately. The majority of the grains are gelatinized in 15 seconds, and all but rare grains (over 99 per cent of both the grains and total starch) in 45 seconds; these grains which are only in the proportion of 1 in several hundred are very resistant.

The reaction with *cobalt nitrate* begins immediately. Complete gelatinization occurs in about 84 per cent of the entire number of grains and 90 per cent of the total starch in 1 minute; in about 95 per cent of the grains and 97 per cent of the total starch in 2 minutes; in about 98 per cent of the grains and over 99 per cent of the total starch in 5 minutes.

The reaction with *copper nitrate* begins immediately. Complete gelatinization occurs in all but rare grains in 1 minute, in all (100 per cent of both the grains and total starch) in 1 minute and 15 seconds.

The reaction with *cupric chloride* begins immediately. Complete gelatinization occurs in about 75 per cent of the entire number of grains and 86 per cent of the total starch in 1 minute; in about 78 per cent of the grains and 90 per cent of the total starch in 2 minutes; in about 93 per cent of the grains and 97 per cent of the total starch in 5 minutes; in about 99 per cent of the grains and in over 99 per cent of the total starch in 15 minutes.

The reaction with *barium chloride* begins in a few grains immediately. Complete gelatinization occurs in about 8 per cent of the entire number of grains and 15 per cent of the total starch in 5 minutes; in about 33 per cent of the grains and 36 per cent of the total starch in 15 minutes; in about 49 per cent of the grains and 55 per cent of the total starch in 30 minutes; in about 53 per cent of the grains and 62 per cent of the total starch in 45 minutes; in about 62 per cent of the grains and 67 per cent of the total starch in 60 minutes. (Chart D 618.)

The hilum is distinct as in *C. lowianum*, and the lamellæ are not so distinct, but more distinct than in *C. eburneum*. Gelatinization, as in the parents, begins at the hilum, and the progress of gelatinization is the same as in *C. lowianum*, except that fissuration is not so extensive, but more extensive than in *C. eburneum*, and lamellation of the marginal band is less obvious. The gelatinized grains are as large and as distorted as in *C. lowianum*. In this reaction *C. eburneo-lowianum* is closer, qualitatively, to *C. lowianum* than to *C. eburneum*.

The reaction with *mercuric chloride* begins immediately. Complete gelatinization occurs in about 70 per cent of the entire number of grains and 78 per cent of the total starch in 1 minute; in about 80 per cent of the grains and 91 per cent of the total starch in 2 minutes; in about 95 per cent of the total starch in 3 minutes; in about 91 per cent of the grains and 98 per cent of the total starch in 5 minutes; in about 98 per cent of the grains and in over 99 per cent of the total starch in 15 minutes.

The hilum and lamellæ are as distinct as in *C. lowianum,* and gelatinization begins at the hilum as in both parents, and the process is the same as described under *C. lowianum,* except that the granules formed of the starch immediately surrounding the hilum are not so numerous as in those grains. The gelatinized grains are large and as distorted as those of *C. lowianum.* In this reaction *C. eburneo-lowianum* shows qualitatively a slightly closer relationship to *C. lowianum* than to *C. eburneum.*

17. CALANTHE.

This genus of sub-epiphytal or terrestrial orchids includes a few species, and there are a number of varieties and hybrids. Starches from the pseudobulbs of the following parent-stocks and hybrid-stocks were studied:

45. *C. rosea* (seed parent), *C. vestita* var. *rubro-oculata* Hort. (pollen parent), and *C. veitchii* Lindl. (hybrid).
46. *C. vestita* var. *rubro-oculata*, Hort. (seed parent), *C. regnieri* (*C. vestita* var. *regnieri* var. *williamsii*) (pollen parent), and *C. bryan* (hybrid).

The specimens were obtained from James Veitch and Sons, London, England.

45. Starches of Calanthe rosea, C. vestita var. rubro-oculata, and C. veitchii.

Calanthe rosea (Seed Parent).

(Charts D 619 to D 626.)

Histologic Properties.*

In *form* most of the grains appear to be simple (as the hilum is rarely demonstrable it can not be definitely asserted) and are isolated with the exception of a few which appear in aggregates, usually of 2 components. Definite compound and semi-compound grains consisting of from 2 to 4 components are rarely observed. No well-defined pressure facets are observed, although flattening either at one end at indefinite points as well as small concave depressions are found. The surface of the grain is generally irregular, which is chiefly due to the following causes: A sinuous to crenate outline, the latter frequently at one end; a difference in the contour of the sides; shifting of the longitudinal axis, sometimes resulting either in one or two abrupt curves; small nipple-like to large protuberances at the proximal end; a protuberance apparently at the distal end, but since a hilum is rarely distinguishable in these grains a definite orientation is difficult; deep concave indentations at varied points more frequently appear to be at the distal end; and occasionally moderately large blunt protuberances at one side which probably represent a secondary growth. The conspicuous forms are almost round; rounded triangular; ellipsoidal, sometimes with slightly broadened and squared diagonal or irregular distal end; pyriform squared at the narrow end; shield-shaped and rhomboidal. The additional forms are perfect ovoid; lenticular; reniform, scroll-shaped, dome-shaped, probably a separated grain, and grains of indefinite form. Most of the grains are very much flattened and when viewed on edge are either narrow lenticular or rod-shape.

The *hilum* is rarely demonstrable, when made out it appears as a small non-refractive spot which varies from centric to quite eccentric, commonly eccentric. Either a small crescentic or lenticular transverse cleft at the hilum, and delicate definite fissures leaving it are rarely observed. The longitudinal fissures appear either as one from each side of the hilum passing obliquely towards the distal margin, or as one median straight, curved or diagonal, which is generally clean-cut, though sometimes either ragged throughout or branched at the distal end. The main body of most of the grains is broken either into refractive masses or granules by irregular translucent branched lines having no connection with the hilum, sometimes the branching being so numerous as to form a network, or the main body may be studded with translucent dots which impart a pitted appearance to this region of the grain. It is uncertain whether these lines are fissures, or whether both lines and dots are related to the inequalities of the surface, and thus simply indicate differences in density. When deeply pitted or divided by a network of lines so as to break the body into granules the grains have the appearance of partial gelatinization. The position of the hilum is centric to quite eccentric, the range of eccentricity varies from 0.33 to 0.1, more frequently about 0.2 of the longitudinal axis. Since the hilum is rarely demonstrable these figures are only provisional.

---

* It is difficult to obtain the percentage of gelatinization with *Calanthe rosea*, *C. veitchii*, and *C. regnieri*. These starch grains are mixed with numerous oxalate needles, *C. regnieri* having the greatest number. When a thin layer of the preparation is made on the slide it is frequently found to contain but a small proportion of starch grains. It is almost impossible to find 100 grains in the field under the high power of the polariscope, and the grains are so small that the process of gelatinization can not be satisfactorily studied under the low powers. It is difficult to obtain more than 40 or 50 grains in the field when working with *C. regnieri*, in such an event it is necessary to repeat the experiment several times in order to eliminate the chance of error. The degree of polarization of the three starches mentioned is low except in the narrow marginal border and, when viewed on edge, the needles are so brilliant and so massed when observed under the polariscope that it is almost impossible to obtain the percentages by means of the polariscope unless the reagent used dissolves these needles; and therefore the results have to be obtained by means of the miscroscope and the polariscope combined, if the latter is at all possible. Most of the grains of the *Calanthe* in the specimens studied have much the appearance of partial gelatinization, and when studied with iodine the reactions are very reddish in tint, resembling the reaction with dextrin; the *Calanthe regnieri* is the farthest removed from the characteristic color reaction of starch with iodine.

These grains are much flattened and often present a pitted appearance, notably in *C. regnieri;* this may be due to partial gelatinization, but as the margin is usually wavy and sometimes even scalloped it might be due to different densities caused by these elevations.

The *Calanthe vestita* var. *rubro-oculata* is quite normal in appearance, the *C. bryan* being more nearly normal than in the three starches mentioned. This hybrid has marked characteristics of both parents, and this fact seems to indicate that the *C. regnieri* grains as noted may be the normal grain for this species. If the *C. regnieri* is a grain of great instability which is readily partially gelatinized, then *C. bryan* inherits this characteristic.

The narrow marginal layer of the species *C. rosea*, *C. veitchii*, and *C. regnieri* is very resistant to most reagents, especially at the proximal end and sides nearby. These layers in the untreated grain may extend around the entire grain or only appear at the proximal end and sides nearby.

The *lamellæ* are not generally demonstrable. The surface of the grain, with the exception of a few large scattered grains, is either homogeneously refractive, or the main body is heterogeneously refractive, and is usually completely surrounded or bounded at the proximal end and sides by a narrow more refractive border in which usually but 1, rarely 2 or 3, lamellæ are demonstrable. The heterogeneous type with refractive border is much more frequent than the homogeneous type.

The *size* varies from the smaller which are 6 by 5μ, to the larger which are 38 by 36μ; commonly about 24 to 22μ in length and breadth. The size of the scattered large grains is not given as it would be misleading in comparative study with other species.

Polariscopic Properties.

The *figure* varies from centric to quite eccentric. The figure is not clean-cut in most of the grains, the lines not being distinct. In such grains a narrow band at the margin is arranged either in the form of a square or rectangular box which is always pierced at the corners, and sometimes as well at 1 or more points on the sides. In the few scattered grains in which the figure is distinct, the lines vary from moderately fine to coarse and either intersect at right angles, obliquely, or are so arranged as to form a mesial line with bisected ends. The lines are more frequently straight but may be either bent or bisected. Occasional double or multiple figures are observed.

The *degree of polarization* varies from low to very high (value 55). In most grains there is a great variation in the same aspect of a given grain since it is either very low or lacking in the mesial portion and usually high in a narrow band at the margin. A few scattered grains occur in which the polarization is high to very high throughout the quadrants.

With *selenite* the quadrants in most of the grains are not well defined with the exception of a narrow border at the margin, while in a few scattered grains they are very sharply defined. They are usually unequal in size, and sometimes irregular in shape. The colors are usually impure; the impurity generally indicated by a purplish and orange color, although a greenish tinge appears in some of the scattered grains with sharply defined quadrants. The colors in these scattered grains are more frequently pure.

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains immediately color a light to moderate (value 40) reddish violet, which quickly becomes moderate to moderately deep with slightly bluer tint, the scattered large grains usually being deeper and bluer in tint than the typical smaller grains. With 0.125 per cent Lugol's solution most of the grains color very light to light with rare moderate reddish violet, most of them become moderate and still remain reddish in tint, but a few become moderately deep and bluish, among which are the scattered large grains, although some of these also remain moderate and reddish in tint. After heating in water until all the grains are gelatinized and then adding 2 per cent Lugol's solution most of the gelatinized *grains* become dark, and a few light blue, all with reddish tint, so that most of them appear a deep purple. Some of the scattered large grains are of a very deep purplish-blue. The *solution* is bluish green. If the preparation is boiled for 2 minutes, and then treated with an excess of 2 per cent Lugol's solution, the typical *grain-residues* become a light blue, and the scattered large ones a deep blue, all with reddish tint; the *capsules* color a wine-red to a deep brownish-red, and the *solution* is a deep bluish-green.

Aniline Reactions.

With *gentian violet* the grains stain immediately very lightly to moderate, more of the former, and in half an hour they become moderate to moderately deep, with a slight predominance of former (value 55). The typical grains are usually lighter at the entire margin of rounded grains and at the distal margin of the slender forms. A few large scattered grains occur in which 1 lamella stains more deeply, cutting off a distal marginal border from the main body; this border occasionally also appears deeper in color.

With *safranin* the grains immediately become light to moderate, fewer of the latter, and in half an hour they are moderate to moderately deep, with a majority of the latter (value 60). The grains stain a little more deeply with safranin than with gentian violet. A variation in the depth of the areas of the different types of grains is the same as with gentian violet.

Temperature Reactions.

The majority of the grains are gelatinized at 74° to 76° C., and all are gelatinized at 75° to 77° C., mean 76° C.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 45 per cent of the entire number of grains and 65 per cent of the total starch in 5 minutes; in about 60 per cent of the grains and 75 per cent of the total starch in 15 minutes; in about 76 per cent of the grains and 88 per cent of the total starch in 30 minutes; in about 78 per cent of the grains and 90 per cent of the total starch in 45 minutes; in about 80 per cent of the grains and 92 per cent of the total starch in 60 minutes. (Chart D 619.)

The hilum is usually not visible, but occasionally appears as a large refractive spot, in which a bubble sometimes forms. The lamellæ are not visible. A narrow refractive band is slowly formed about the margin of the grain and recedes before the advance of gelatinization from the margin. The material of the grain usually assumes a pitted appearance before gelatinization begins, and gelatinization may begin either in the interior of the grain or at prominent points of the distal margin. In the first-named grains gelatinization of the whole grain proceeds with great rapidity, and much swelling; in the second-named grains the distal marginal starch gelatinizes and gelatinization proceeds toward the proximal end. The ungelatinized material separates in successive layers, suggesting a lamellar structure, which is not otherwise demonstrable. Gelatinization as a rule proceeds more rapidly along the margin than in the interior of the grain, and therefore the gelatinized marginal starch may completely surround the more resistant inner starch. The most resistant starch is usually found just distal to the hilum if the hilum is visible, otherwise in the central portion of the grain. The gelatinized grains are large and much distorted, and do not retain much of the original form of the grain.

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 7 per cent of the entire number of grains and 64 per cent of the total starch in 5 minutes; in about 64 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 98 per cent of the entire number of grains and over 99 per cent of the total starch in 30 minutes; in about 99 per cent of both the grains and total starch in 45 minutes; rare lenticular grains are not completely gelatinized in 60 minutes. (Chart D 620.)

The reaction with this specimen is difficult to follow since many oxalate needles are present, and during solution they cause an evolution of bubbles which as they break produce a current that carries the grains out of the field; furthermore solution of the grains takes place following gelatinization and hence if a current draws them from the field it is difficult to estimate in a new field as to how many have been dissolved. The preparation must consist of a very thin layer of starch and must be constantly kept under observation. If a comparatively small number of needles are present, the bubbles may remain comparatively small and hence prevent currents from carrying the grains out of the field. During solution the grains become very light and motion may occur, causing grains to leave the field. It is difficult to estimate the total starch gelatinized because the grains, with exception of a narrow border, appear as though partially gelatinized and under the polariscope show an exceedingly low or no degree of polarization. Scattered among these grains are a few of very regular outline and moderately high degree of polarization; these grains are quite resistant to gelatinization. The reaction begins in the grains (with main body of apparently uneven density) by the appearance of irregular fissures which break this region into refractive masses and finally into granules. Two fissures usually start from one point which gradually appears to be a hilum in the grains of even density throughout, later these may either form clusters of delicate branches breaking the main body into irregular masses, or the two main branches may extend around the main body until they meet at the distal end, the main body undergoing gelatinization previous to the narrow very refractive border. In elongated grains the border at the distal margin is gelatinized before the proximal end and sides; and in solution is broken first at this point, later one side is frequently dissolved more quickly than the other. The gelatinized grains are somewhat swollen and are not generally distorted; a narrow border which is very refractive and generally consists of but one lamella is very resistant and frequently remains unless the grains become dissolved. Previous to solution this lamella becomes striated and breaks into linearly arranged granules.

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in about 10 per cent of the entire number of grains and 30 per cent of the total starch in 5 minutes; in about 26 per cent of the grains and 60 per cent of the total starch in 15 minutes; in about 34 per cent of the grains and 92 per cent of the total starch in 30 minutes; in about the same percentage of the grains and 95 per cent of the total starch in 45 minutes; in about 52 per cent of the grains and 96 per cent of the total starch in 60 minutes. (Chart D 621.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 27 per cent of the entire number of grains and 74 per cent of the total starch in 5 minutes; in about 50 per cent of the grains and 82 per cent of the total starch in 15 minutes; in about 52 per cent of the grains and 87 per cent of the total starch in 30 minutes; in about 54 per cent of the grains and 90 per cent of the total starch in 45 minutes; in about 59 per cent of the grains and 95 per cent of the total starch in 60 minutes. (Chart D 622.)

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 93 per cent of the entire number of grains and 98 per cent of the total starch in 3 minutes; in more than 99 per cent of the grains and total starch in 5 minutes. (Chart D 623.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 22 per cent of the entire number of grains and 84 per cent of the total starch in 5 minutes; in about 41 per cent of the grains and 92 per cent of the total starch in 15 minutes; in about 50 per cent of the grains and 95 per cent of the total starch in 30 minutes; in about 71 per cent of the grains and 96 per cent of the total starch in 45 minutes; in about 77 per cent of the grains and 97 per cent of the total starch in 60 minutes. (Chart D 624.)

Gelatinization in the majority of grains begins at the margin, usually the distal end when this region is clearly defined, and is frequently accompanied with considerable distortion. The narrow refractive border is generally crenate and following the gelatinization at the indented points may become broken into concave brilliant segments. Two fissures may proceed from the hilum of scattered broadly triangular grains which are homogeneously refractive and have but a slightly sinuous outline; these fissures proceed distalwards and form the boundary between a narrow refractive border and the mesial region, which region is more quickly gelatinized, parts of the refractive border especially at and near the proximal end being quite resistant. A few medium-sized grains, which are very refractive, are found in which 1 or 2 very sharply defined fissures proceed from the hilum; these grains are much more resistant than those previously mentioned. At the end of the experiment (60 minutes) the majority of the grains are gelatinized and many have been dissolved, while many more are in various stages of disintegration. Scattered among these are a few with a broad, refractive border bounding a mass of refractive granules. The grains are much swollen and undergo considerable distortion during gelatinization and disintegration.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 10 per cent of the grains and 78 per cent of the total starch in 5 minutes; in about 18 per cent of the grains and 88 per cent of the total starch in 15 minutes; in about 22 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 27 per cent of the grains and 93 per cent of the total starch in 45 minutes; in about 29 per cent of the grains and 95 per cent of the total starch in 60 minutes. (Chart D 625.)

The hilum becomes visible in some grains in which hitherto it was not demonstrable, and more distinct in others in which it could be demonstrated before treat-

ment with the reagent. Lamellæ also become more distinct in some grains. Gelatinization begins in the interior of the grain, in many at the hilum or some point corresponding to it, and delicate branching fissures proceed from this point fanwise to the margin and divide the material of the grain into two granules, and as these slowly gelatinize the grain swells slowly and becomes more nearly transparent until they are finally completely gelatinized. In the majority of the grains, however, translucent lines appear running criss-cross in all directions through the grain, dividing the whole interior into granules of various sizes and then into fragments which gradually separate from one another, all the while becoming more translucent, until they are gelatinized with much folding of the capsules of the grains. The gelatinized grains are moderately large and very much distorted. Sometimes the capsule is dissolved and then the contents of the capsule before gelatinization is complete.

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 68 per cent of the entire number of grains and 76 per cent of the total starch in 3 minutes; in about 84 per cent of the grains and 93 per cent of the total starch in 5 minutes; in about 96 per cent of the grains and 98 per cent of the total starch in 10 minutes. (Chart D 626.)

The hilum and the lamellæ are not visible in most of the grains. A very narrow and not very refractive band is formed about the margin of the grain before gelatinization begins. Gelatinization begins at various points around the margin, usually at small projections from the margin, and progresses from these points around the margin, until all the marginal starch is somewhat irregularly gelatinized. It then progresses inward, the ungelatinized part of the grain assuming first a pitted and then a finely granular appearance and then becoming gelatinized. The central part of the grain is the most resistant, and this is usually split into several pieces which are gelatinized separately, but occasionally small granules only are broken off until all is gelatinized. The gelatinized grains are large and very much distorted and show very little resemblance to the form of the untreated grain.

Calanthe vestita var. rubro-oculata (Pollen Parent).

(Charts D 619 to D 626.)

Histologic Properties (See Foot-note, page 769).

In *form* most of the grains are simple and isolated, with the exception of a few which appear as aggregates usually of 2 components. Compound and semi-compound grains of 2 components are occasionally observed. Well-defined pressure facets are occasionally observed. The surface of the grain is frequently regular, but slight irregularity may be observed, which is chiefly due to the following causes: A shifting of the longitudinal axis which is occasionally quite abrupt; a difference in the contour of the sides in an otherwise regular grain; occasional sinuous outline, and to a rounded or blunt lateral swelling. The conspicuous forms are ovoid, ellipsoidal, pyriform, almost round, and rounded triangular. In addition there are ovoid with squared or broadened and concave distal end, reniform, irregular rhomboidal, and pyriform abruptly curved at narrow end. The clearly defined separated grains are usually dome-shaped, but as the components of aggregates frequently are placed laterally and are either somewhat pyriform or ovoid in shape; grains with one side more flattened may be separated grains. The grains vary from slightly to moderately flattened, with more of the former when seen on edge; they are either ovoid or narrow ellipsoidal.

The *hilum* is either a round or lenticular spot which is usually non-refractive; when lenticular it may be located either transversely or diagonally. Either a small rounded or lenticular cavity is sometimes present. The hilum is more frequently fissured, usually by 1 transverse straight, crescentic or irregularly bent cleft, or a group of irregularly placed clefts; and clefts so arranged as to form a soaring-bird figure. Longitudinal fissures frequently leave the hilum, such as 1 straight or diagonal, which may be either clean-cut or branched and 2 which are directed obliquely towards the distal corners. The fissures both at and proceeding from the hilum are usually deep and refractive. The position varies from centric to quite eccentric; the range of eccentricity varies from 0.42 to 0.12, commonly about 0.33 of the longitudinal axis.

The *lamellæ* are not usually demonstrable, but occasionally 1 or 2 are distinct and moderately coarse. When 2 are present, 1 forms a circular ring directly around the hilum, and the other one a short distance from it. If but 1 lamella is distinct it is generally located moderately near the margin, at which region a band then appears, even more refractive than the main body of the grain. A few lamellæ are occasionally demonstrable in the main body of the grain, being bounded by a refractive marginal border. Lamellæ in the blunt protuberances at one side of the grain were not demonstrable, although this probably represents a secondary growth. Rarely 16 can be counted on medium-sized grains, 29 on large pyriform grains. These larger grains are scattered among the more common medium-sized grains.

The *size* of the grains varies from the smaller, which are 5 by 4μ, to the larger, which are 40 by 28μ in length and breadth. The common size is about 22 by 18μ in length and breadth.

Polariscopic Properties.

The *figure* varies from centric to quite eccentric, more of the eccentric, and is more frequently clean-cut. The lines in most grains are moderately fine, often broadening towards the margin and usually intersecting either at right angles or obliquely, though occasionally arranged in a median line with bisected ends. The lines are more frequently straight, although they are moderately often bent and bisected. In a few grains the lines are broad, or rarely an arrangement is found which resembles a rectangular box open at the corners, infrequently pierced at one or more points on the sides. Double and multiple figures are observed.

The *degree of polarization* is moderate to very high, commonly high (value 70), much higher than in *C. rosea*. There is also considerable variation in the same aspect of a grain, a small proportion of them, either the central part or the lower median quadrant, being exceedingly low.

With *selenite* the quadrants of the majority are sharply defined, unequal in size, and slightly to quite irregular in shape. The colors are usually pure, the

yellow somewhat less often than the blue. Impurity is occasionally observed either by an orange and purplish color, a greenish tinge to both colors.

Iodine Reactions.

With 0.25 per cent Lugol's solution most of the grains color a moderate violet (value 50) which quickly deepens to a very deep blue. With 0.125 per cent Lugol's solution the grains at once color a light violet which quickly deepens to moderately deep with bluer tint. After heating the grains in water until they are gelatinized and then adding 2 per cent Lugol's solution the gelatinized grains become a moderate to deep blue, many with reddish tint; somewhat more of the latter with the reddish tint, which gives them a purplish color; the *solution* becomes a moderately deep greenish-blue. If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution the *grain-residues* color a light blue with reddish tint, and the *capsules* a deep old-rose to deep amethyst or reddish-heliotrope; and the *solution* a deep greenish-blue.

Comparison with *C. rosea* shows:

With 0.25 per cent Lugol's solution the grains immediately, as well as later, are deeper, bluer with variation than in *C. rosea.* With 0.125 per cent solution the grains immediately as well as finally are deeper blue and less variation than in *C. rosea.* After gelatinization and treating with iodine, the mean of the gelatinized grains is a little lighter and the solution bluer. When the preparation is boiled and treated with an excess of iodine the grain-residues slightly lighter, the capsules less yellowish in tint and the solution more bluish.

Aniline Reactions.

With *gentian violet* the grains color lightly at once, some slightly deeper than others, but not much variation; in 30 minutes they become moderate to deep (value 60) with more of the latter. The hilum and fissures are slightly deeper and more rose-violet, the 1 or 2 coarser lamella present stain more deeply.

Comparison with *C. rosea* shows:

With *gentian violet* the grains color at once with less variation in the different grains than in *C. rosea;* and in half an hour the mean is a little deeper in color. In the same aspect of a given grain the 1 or 2 lamellæ of deeper color are more frequent, but a marginal border of lighter color is not evident as in *C. rosea.* With *safranin* the grains immediately color about the same as *C. rosea,* and in half an hour the mean is deeper. The variation in depth in the same aspect of a given grain is the same as with gentian violet.

With *safranin* the grains immediately color light to moderate, deeper than with gentian violet: and in 30 minutes they become moderate to moderately deep with many more of the latter (value 65). There is the same variation in the depth of the different parts of the grain as with gentian violet.

Temperature Reactions.

The majority of the grains are gelatinized at 72° to 74° C., and of all at 74° to 75° C., mean 74.5° C. A few of the marginal lamellæ are much more resistant than other parts, all but these being gelatinized in most of the grains at 65° to 67° C., but parts of these lamellæ resist gelatinization in many grains until the temperature of 72° to 74° C., mean 73° C., is reached, as above stated. The gelatinized grains are much swollen, and much convoluted at the distal margin.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 22 per cent of the entire number of grains and 40 per cent of the total starch in 5 minutes; in about 35 per cent of the grains and 53 per cent of the total starch in 15 minutes; in about 44 per cent of the grains and 58 per cent of the total starch in 30 minutes; in about 49 per cent of the grains and 60 per cent of the total starch in 45 minutes; in about 50 per cent of the grains and 62 per cent of the total starch in 60 minutes. (Chart D 619.)

The hilum, differing from the grains of *C. rosea,* becomes very distinct in all the grains and a bubble is frequently formed there, and any fissures present in the untreated grain become deeper and wider. The lamellæ also become distinct, at first, only in a broad refractive band which is quickly formed about the margin of the grain and which is broader and more distinct than in *C. rosea* but later in all parts of the grain, and in a few grains they are never distinct. Gelatinization begins in several ways: in some grains the hilum swells suddenly and the starch between it and some part of the margin gelatinizes rapidly, thus producing an apparent extension of starch which is, however, still retained within the capsule; in other grains which are triangular in shape, the proximal end and the hilum gelatinize first; and in still others which are nearly round, or broad ovoid, gelatinization begins at some one point on the margin, in this somewhat resembling some of the grains of *C. rosea.* In the first and third methods gelatinization progresses from the initial point of attack evenly all over the grain, the deep fissures already noted proceeding further and further from the hilum until they reach the margin but do not break the capsule, the pieces of starch thus separated are rapidly gelatinized, the portion just distal to the hilum being the most resistant and this corresponds probably to the more central portion of the grains of *C. rosea.* In the second method a point on the margin and the hilum are affected simultaneously, the hilum swells very rapidly, and if a bubble is present, it swells, then shrinks and disappears, and the starch between the hilum and the margin is gelatinized rapidly; from this point the progress is the same as in the first method. Some of the gelatinized grains unlike those of *C. rosea* have very thick capsular walls and are not greatly distorted, while others have thinner capsules and are larger and more distorted but not so much as in *C. rosea.*

The reaction with *chromic acid* begins in 1 minute. Complete gelatinization occurs in about 0.5 per cent of the entire number of grains and 10 per cent of the total starch in 5 minutes; in about 1 per cent of the grains and 65 per cent of the total starch in 15 minutes; in about 10 per cent of the grains and 80 per cent of the total starch in 30 minutes; in about 14 per cent of the grains and 92 per cent of the total starch in 45 minutes; in about 32 per cent of the grains and 96 per cent of the total starch in 60 minutes. (Chart D 620.)

This preparation is more easily followed than in *C. rosea* since there are fewer oxalate needles, hence much less disturbance from the evolution of bubbles, and there is very little solution of entire grains. The grains of this species are apparently of even density throughout and usually of regular outline, very much more than in *C. rosea;* when the larger grains are observed under the polariscope, however, the mesial portion has a lower degree of polarization than the margin.

Gelatinization begins and proceeds as noted for the grains of even density and regular form in *C. rosea.* The narrow border of more resistant starch frequently consists of 2 or 3 clearly defined lamellæ which are striated and may later break into linearly arranged refractive granules; this border is generally broader than in *C. rosea.* The border may become dissolved at the distal end, but the entire grains are not usually dissolved; this border is far more resistant than in *C. rosea.* The gelatinized grains are somewhat swollen but not usually distorted as in *C. rosea;* a large proportion do not become completely gelatinized since the narrow border above noted resists the reagent.

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in but rare grains, less than 0.5 per cent of the entire number, and 10 per cent of the total starch in 5 minutes; complete gelatinization still occurs in less than 0.5 per cent of the entire number of grains and 20 per cent of the total starch in 15 minutes; complete gelatinization occurs in about 1 per cent of the entire number of grains and 60 per cent of the total starch in 30 minutes; in about 8 per cent of the entire number of grains and 84 per cent of the total starch in 45 minutes; in about 15 per cent of the grains and 89 per cent of the total starch in 60 minutes. (Chart D 621.)

The reaction with *nitric acid* begins immediately in a few grains. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 61 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 64 per cent of the total starch in 15 minutes; in about 13 per cent of the grains and 71 per cent of the total starch in 30 minutes; in about 15 per cent of the grains and 73 per cent of the total starch in 45 minutes; in about 18 per cent of the grains and 78 per cent of the total starch in 60 minutes. (Chart D 622.)

The reaction begins immediately; a few grains are gelatinized in 15 minutes; the majority in 1 minute; nearly all in 1½ minutes, all but a few resistant grains in 2 minutes and all in 3 minutes. A small bubble appears at the hilum and is soon expelled; fissures proceed from the swollen hilum to the distal margin, and when these fissures are obliquely directed towards the distal corners, the lamellæ between them become sharply defined and striated. Gelatinization proceeds more rapidly now at the distal margin and then the refractive granules of the mesial region gradually become gelatinized, a group around the hilum, frequently being larger, more refractive, and quite resistant. A narrow refractive band at the proximal end and sides is the most resistant starch; this gradually becomes sharply defined into 2 or 3 lamellæ which are deeply striated but not usually broken down into linear granules previous to gelatinization. The gelatinized grains are much swollen and distorted, the latter greater at the distal margin. They do not resemble the untreated grain.

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 60 per cent of the entire number of grains and 81 per cent of the total starch in 3 minutes; in about 96 per cent of the grains and in more than 99 per cent of the total starch in 5 minutes. (Chart D 223.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 18 per cent of the total starch in 5 minutes; in about 3 per cent of the grains and 33 per cent of the total starch in 15 minutes; in about 7 per cent of the grains and 64 per cent of the total starch in 30 minutes; in about 14 per cent of the grains and 71 per cent of the total starch in 45 minutes; in about 17 per cent of the grains and 78 per cent of the total starch in 60 minutes. (Chart D 624.)

Gelatinization is usually preceded by the appearance of 2 clearly defined fissures which proceed from the hilum and extend distalwards, sometimes meeting at the distal end; these fissures sharply define the mesial region from a very refractive border. Deep irregularly arranged fissures frequently form between these 2 fissures at the distal end, especially if they are not confluent, and this region is more quickly disorganized, followed later either by disintegration or by gelatinization. The mesial region is finally broken into an irregular mass of brilliant granules while the border, which extends around the proximal end and sides, remains very refractive and profusely striated. The grains are considerably swollen but very rarely are distorted unless disintegration, followed by a process of solution, is proceeding; a very small proportion of grains are completely gelatinized and a few medium-sized grains are but little affected by the reagent.

Comparison with *C. rosea* shows:

Fissures proceeding from a definite hilum are much more frequently demonstrable, and they form the boundary between a much broader refractive border and a mesial mass of much more refractive granules than in *C. rosea.* The grains are much more resistant, show much less distortion (practically none), and there is very little disintegration, much less than in *C. rosea.*

The reaction with *potassium hydroxide* begins in a few grains immediately. Complete gelatinization occurs in about 3 per cent of the entire number of grains and 54 per cent of the total starch in 5 minutes; in about 6 per cent of the entire number of grains and 65 per cent of the total starch in 15 minutes; in about 9 per cent of the grains and 72 per cent of the total starch in 30 minutes; in about 12 per cent of the grains and 75 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 77 per cent of the total starch in 60 minutes. (Chart D 625.)

The hilum becomes more distinct than in those grains of *C. rosea* in which it is demonstrable, and any fissures present become wider and more extensive, and often reach almost to the margin. The lamellæ become very distinct at first but later are obscured. Gelatinization begins at the hilum which enlarges somewhat, and the starch immediately surrounding it becomes divided into coarse granules and the rest of the grain is covered by fine striæ which become less fine and more evident as gelatinization progresses, and finally as the hilum en-

larges and the grain swells a broad, striated marginal band is formed by the more resistant starch which is divided into many wedge-shaped portions by wide fissures. This band becomes narrower and more nearly transparent, the granules which were first formed about the hilum are gelatinized and the grain is gelatinized. In a small number of grains the capsule is dissolved and the contents flow out and are dissolved before gelatinization is complete, but in not so many as in *C. rosea.* The gelatinized grains are larger than in *C. vestita* var. *rubro-oculata,* and have thicker capsules and retain more of the form of the untreated grain.

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 12 per cent of the entire number of grains and 15 per cent of the total starch in 5 minutes; in about 75 per cent of the grains and 83 per cent of the total starch in 15 minutes; in about 98 per cent of the grains and in more than 99 per cent of the total starch in 30 minutes. (Chart D 626.)

The hilum unlike *C. rosea* is usually moderately distinct, and a small bubble is formed there. The lamellæ are not visible. As in *C. rosea* a narrow and not very refractive band is formed about the margin before gelatinization begins and is more noticeable at the proximal end than elsewhere. Gelatinization, unlike the grains of *C. rosea,* begins at the distal margin where it is preceded by a pitted appearance of the surface of the grain, and proceeds evenly toward the proximal end, by causing small granules to be broken off from the edges of the ungelatinized starch and gelatinized. After the lower third of the grain has been gelatinized, two methods of progress are noted, of which the first is seen in the less resistant grains. A refractive line extends centrally from the hilum to the gelatinized starch at the distal end; the hilum swells slightly, the bubble enlarges very little, then shrinks and disappears, and the central portion of the grain, along the refractive line already mentioned, gelatinizes, leaving the marginal and proximal starch ungelatinized; these later gelatinize, the proximal starch being the most resistant. In the more resistant grains the other method is noted, and this consists of an even progression of gelatinization upward in all parts of the grain until the hilum is reached, which swells slightly, the bubble shrinks and disappears, and the proximal starch, which is the most resistant, is broken into 2 or 3 pieces which are slowly gelatinized. The gelatinized grains as in *C. rosea* are large and considerably distorted, and do not have much of the form of the untreated grain.

Calanthe veitchii (Hybrid).

(Charts D 619 to D 626.)

Histologic Properties (See Foot-note, page 769).

In *form* most of the grains appear to be simple and are isolated with the exception of a few which are found in aggregates of from 2 to 3 components. The aggregates are more numerous than in *C. rosea,* about as in *C. vestita* var. *rubro-oculata.* Compound and semi-compound grains are rarely observed, somewhat more frequently than in *C. rosea,* less frequently than in *C. vestita* var. *rubro-oculata.* The separation of the grains into simple, compound, etc., is difficult to make since the hilum is frequently not demonstrable. Well-defined pressure facets are occasionally observed, much more frequently than in *C. rosea,* about as in *C. vestita* var. *rubro-oculata.* The surface of the grain is frequently irregular, due to the same causes as found in both parents, somewhat less than in *C. rosea,* but much more than in *C. vestita* var. *rubro-oculata.* The conspicuous forms are ellipsoidal, sometimes broadened and squared or irregular at the distal end, nearly round, pyriform, ovoid, reniform, and rounded triangular. The additional forms are round, rounded with raised rounded prominence at proximal end, irregular rhomboidal, pyriform with narrower end curved, and grains of indefinite shape. The clearly defined separated grains are dome-shaped, but the components of aggregates are frequently placed laterally, and hence other forms with one side flattened are probably separated grains. These separated grains are more numerous and well defined than in *C. rosea,* about as in *C. vestita* var. *rubro-oculata.* The grains vary from slightly to much flattened, with somewhat more of the latter, not quite so much flattened as in *C. rosea,* but more than in *C. vestita* var. *rubro-oculata.* When viewed on edge they have the same shape as in both parents. In form most of the grains are closer to *C. rosea,* but some of them are the same as in *C. vestita* var. *rubro-oculata.*

The *hilum* is more frequently undemonstrable but is distinct in more grains than in *C. rosea,* but in not nearly so many as *C. vestita* var. *rubro-oculata.* When observed it is usually a small and not a refractive round or lenticular spot, sometimes refractive. A small rounded cavity is occasionally present. A small transverse or crescentic cleft is occasionally present at the hilum, somewhat more frequently than in *C. rosea,* but not nearly so frequently as in *C. vestita* var. *rubro-oculata.* Definite longitudinal usually non-refractive fissures leaving the hilum are often observed, considerably more frequent and varied than in *C. rosea,* but much less deep, varied, and frequent than in *C. vestita* var. *rubro-oculata.* The fissures leaving the hilum are usually 1 median which may be quite deep and rarely refractive, and is either clean-cut throughout or becomes much branched towards the distal end; 2 leaving the hilum, which are directed obliquely towards the distal corners; and a group of undulating fissures directed towards the distal end, which are sometimes bounded by the 2 obliquely directed fissures. The main body in the majority of grains is broken usually into refractive masses, and occasionally into large granules by irregular branched translucent lines which may be so numerous as to form a network, or this main body may be studded with numerous translucent dots which impart a pitted appearance to this region of the grain; fewer of such grains appear, especially of the latter type than in *C. rosea,* but many more than in *C. vestita* var. *rubro-oculata,* since such grains were not observed in *C. vestita* var. *rubro-oculata.* The position of the hilum varies from centric to quite eccentric. The range of eccentricity varies from 0.4 to 0.14, more frequently about 0.33 of the longitudinal axis. Since the hilum is more frequently undemonstrable, these figures must be considered provisional.

The hilum is usually not demonstrable as in most of the grains of *C. rosea,* and when it is demonstrable, the character is closer to that of the grains of *C. rosea.*

The *lamellæ* are not generally demonstrable but grains with a homogeneously refractive surface with the exception of 1 distinct lamella are more frequent than in

C. rosea, though much less frequent than in *C. vestita* var. *rubro-oculata.* In the main body of the majority of grains no lamellæ are demonstrable, but this region is heterogeneously refractive and is often bounded either by an entire or a proximal and lateral more refractive border, in which 1 to about 3 marginal lamellæ may be clearly defined; such grains are less frequent, and the main body less often inclosed within a refractive border than in *C. rosea,* such grains were not observed in *C. vestita* var. *rubro-oculata.*

The lamellæ are usually not demonstrable as in most of the grains of *C. rosea* and the grains in which they are demonstrable are closer to similar grains in *C. rosea.*

The *size* of the grain varies from the smaller which are 8 by 6μ, to the larger which are 36 by 24μ, commonly 21 by 16μ, in length and breadth. In size and proportion the grains are closer to *C. vestita* var. *rubro-oculata.*

Polariscopic Properties.

The *figure* varies from centric to quite eccentric, in most grains it is not distinct and clean-cut, although somewhat more frequently than in *C. rosea,* but much less than in *C. vestita* var. *rubro-oculata.* A narrow band at the margin of the majority of grains is arranged like a box, with somewhat less frequency than in *C. rosea,* but with very much more than in *C. vestita* var. *rubro-oculata.* When the figure is clean-cut the lines vary from moderately fine to coarse, more of the moderately fine than in *C. rosea,* but much less than in *C. vestita* var. *rubro-oculata.* The lines when distinct are arranged as in both parents.

The *degree of polarization* varies from low to very high (value 60), and there is the same variation in the different grains as in *C. rosea,* but more than in *C. vestita* var. *rubro-oculata.* There is somewhat less variation in the same aspect of a given grain, and hence the mean is higher than in *C. rosea,* but there is usually much more variation with the mean much lower than in *C. vestita* var. *rubro-oculata.*

With *selenite* the quadrants are usually not distinct, excepting at the margin, though somewhat more frequently in the typical grains than in *C. rosea,* but much less frequently than in *C. vestita* var. *rubro-oculata.* The colors are generally impure, about as in *C. rosea,* the impurity usually indicated by an orange and purplish color as in *C. rosea.* The scattered large grains with sharply defined quadrants are more rare than in *C. rosea;* when present the colors are usually tinged with green, as in similar grains of *C. rosea;* the colors are much more frequently impure than in *C. vestita* var. *rubro-oculata.*

In degree of polarization, character of the figure, and appearance with selenite the grains of *C. veitchii* are closer to *C. rosea.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains color a moderate violet (value 43), a little deeper, bluer, and with less variation than in *C. rosea,* slightly lighter and less bluish than in *C. vestita* var. *rubro-oculata;* the color deepens, rare large grains being deeper and slightly bluer than the others, a little deeper, bluer, and with less variation among the grains than in *C. rosea,* almost as deep with a little more variation than in *C. vestita* var. *rubro-oculata.* With 0.125 per cent Lugol's solution, the *grains* immediately color a light violet, they quickly become moderately deep and bluer in tint with the rare larger grains deeper and a little bluer; most of the grains are a little bluer and deeper than in *C. rosea,* slightly lighter and less bluish than in *C. vestita* var. *rubro-oculata.* After heating in water until the grains are gelatinized and then adding a 2 per cent Lugol's solution the gelatinized typical *grains* become a light to moderate blue with reddish tint, lighter and more reddish than in both parents; the rare large grains are a deep purplish-blue about as in *C. rosea,* these grains are not observed in the preparation of *C. vestita* var. *rubro-oculata;* the *solution* becomes a deep bluish-green, a little deeper and bluer than in *C. rosea,* more greenish than in *C. vestita* var. *rubro-oculata.* If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution most of the *grain-residues* become a very light blue with reddish tint, rare large grains moderately deep blue with reddish tint, slightly lighter than in both parents; the reddish tint nearer *C. rosea* than *C. vestita* var. *rubro-oculata;* the *capsules* are moderate old-rose to brick-red, lighter but very much the tint of *C. rosea,* lighter and more yellowish in tint than in *C. vestita* var. *rubro-oculata.* The *solution* becomes a very greenish-blue, less greenish in tint than in *C. rosea,* but more than in *C. vestita* var. *rubro-oculata.* Qualitatively and quantitatively the reaction with iodine is slightly closer to *C. rosea* than to *C. vestita* var. *rubro-oculata.*

Aniline Reactions.

With *gentian violet* the grains color lightly at once, some a little deeper than others, less variation than in *C. rosea,* about as in *C. vestita* var. *rubro-oculata;* in 30 minutes they are moderate to moderately deep (value 57) with somewhat more of the latter, the mean is a trifle deeper but nearly the same tint as in *C. rosea;* the mean a little lighter but a little more reddish than in *C. vestita* var. *rubro-oculata.* The same variation in depth of the areas is present but less marked than in *C. rosea,* but more prominent, with exception of the fissures, than in *C. vestita* var. *rubro-oculata.*

With *safranin* the grains color light to moderate at once, the mean about the same as in the parents; in 30 minutes they become moderate to moderately deep, with many more of the latter (value 65), the mean is a little deeper than in *C. rosea,* and about the same depth as in *C. vestita* var. *rubro-oculata.* The areas are about the same as with gentian violet.

The reaction with gentian violet is midway between the two parents; that with safranin the same as that of *C. vestita* var. *rubro-oculata.*

Temperature Reactions.

The majority of the grains are gelatinized at 71° to 72° C., and all at 73° to 74° C., mean 72.5° C. The mean temperature of gelatinization is less than that of either parent, and is closer to that of *C. vestita* var. *rubro-oculata.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 60 per cent of the grains and 80 per cent of the total starch in 5 minutes; in about 94 per cent of the grains and 96 per cent of the total starch in 15 minutes; in about 98 per

cent of the grains and 99 per cent of the total starch in 30 minutes. (Chart D 619.)

The hilum sometimes, as in *C. vestita* var. *rubro-oculata,* becomes very distinct, and a bubble may be found there, but in other grains it is not visible. The lamellæ are not visible. A refractive band as in the parents soon appears about the margin of many of the grains, and may be observed to spread inward over the inner portion of the grain just preceding gelatinization. Gelatinization, rarely, begins in the interior of the grain, and usually at what is presumably the distal margin. From this point it progresses inward, the grain often giving the same evidence of a lamellated structure as was noted in *C. rosea.* The marginal material, however, appears to be just as resistant as the rest and the proximal margin is sometimes the last point to be gelatinized, the hybrid in this differing somewhat from both parents. Usually the material just distal to the hilum is the most resistant, as is noted of some grains in both parents. The gelatinized grains are moderately large, but not so large nor so distorted as those of *C. rosea,* in this resembling *C. vestita* var. *rubro-oculata.* In this reaction the grains of *C. veitchii* show qualitatively a slightly closer relationship to the grains of *C. vestita* var. *rubro-oculata* than to *C. rosea.*

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 4 per cent of the entire number of grains and 66 per cent of the total starch in 5 minutes; in about 70 per cent of the grains and 98 per cent of the total starch in 15 minutes; in about 98 per cent of the grains and over 99 per cent of the total starch in 30 minutes; and over 99 per cent of both the grains and total starch in 45 minutes; parts of rare grains may remain ungelatinized for 60 minutes. (Chart D 620).

The hilum is distinct in more grains than in *C. rosea,* but in much fewer than in *C. vestita* var. *rubro-oculata.* Lamellæ also may be observed in more grains than in *C. rosea,* but these are later obscured. Gelatinization begins in the interior of the grain at the hilum, if such be demonstrable, and 2 branching fissures proceed to the distal end which divide the grain into fine granules as in the parents. The remainder of the process resembles that described under *C. rosea,* except that the grains are not dissolved so rapidly as in those grains, but more rapidly than in *C. vestita* var. *rubro-oculata.* In this reaction the grains of *C. vestita* are closer qualitatively to those of *C. rosea* than to those of *C. vestita* var. *rubro-oculata.*

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in about 1 per cent of the entire number of grains and 27 per cent of the total starch in 5 minutes; in about the same percentage of the grains and 54 per cent of the total starch in 15 minutes; in about 22 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 36 per cent of the grains and 93 per cent of the total starch in 45 minutes; in about 41 per cent of the grains and 94 per cent of the total starch in 60 minutes. (Chart D 621.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 27 per cent of the entire number of grains and 76 per cent of the total starch in 5 minutes; in about 36 per cent of the grains and 89 per cent of the total starch in 15 minutes; in about 39 per cent of the grains and 90 per cent of the total starch in 30 minutes; in about 42 per cent of the grains and 92 per cent of the total starch in 45 minutes; in about 43 per cent of the grains and 96 per cent of the total starch in 60 minutes. (Chart D 622.)

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 93 per cent of the entire number of grains and 99 per cent of the total starch in 3 minutes; in more than 99 per cent of the grains and total starch in 5 minutes. (Chart D 623.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 33 per cent of the entire number of grains and 89 per cent of the total starch in 5 minutes; in about 60 per cent of the grains and 95 per cent of the total starch in 15 minutes; in about 80 per cent of the grains and 97 per cent of the total starch in 30 minutes; in about 89 per cent of the grains and 98 per cent of the total starch in 45 minutes; in about 91 per cent of the grains and 99 per cent of the total starch in 60 minutes. (Chart D 624.)

Gelatinization begins and proceeds about as in both parents, the resemblance being much closer to that of *C. rosea* than to *C. vestita* var. *rubro-oculata.* In the majority of grains the marginal border is much narrower and much less resistant than in *C. vestita* var. *rubro-oculata;* it resembles *C. regnieri* closely in width but is less resistant. At the close of the experiment (60 minutes) the grains present a much more varied appearance than in either parent, most of them are completely gelatinized with more distortion, while a few are either very little affected or have a broad border bounding a mass of refractive granules. Disintegration and solution occur in many grains, more than in either parent. The gelatinized grains are swollen and more distorted than in either parent.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 15 per cent of the entire number of grains and 61 per cent of the total starch in 5 minutes; in about 20 per cent of the grains and 81 per cent of the total starch in 15 minutes; in about 27 per cent of the grains and 85 per cent of the total starch in 30 minutes; in about 34 per cent of the grains and 92 per cent of the total starch in 45 minutes; in about 42 per cent of the grains and 95 per cent of the total starch in 60 minutes. (Chart D 625.)

The hilum is distinct and demonstrable in more grains than in *C. rosea,* but in much fewer than in *C. vestita* var. *rubro-oculata,* as are also the lamellæ. Gelatinization in the majority of the grains begins at the hilum (or some point representing the hilum) and proceeds as in *C. vestita* var. *rubro-oculata,* except that the striæ are not so distinct and are finer than in those grains and there are a moderate number of grains in which the type of gelatinization is the same as described for the majority of the grains of *C. rosea,* but there are more grains in which dissolution of the capsule and contents is effected than in *C. vestita* var. *rubro-oculata.* The gelatinized grains are not very large but are considerably distorted as in *C. rosea.* In this reaction the grains of *C. veitchii* are slightly closer, qualitatively, to *C. vestita* var. *rubro-oculata* than to *C. rosea.*

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 82 per

cent of the entire number of grains and 89 per cent of the total starch in 3 minutes; in about 94 per cent of the grains and 97 per cent of the total starch in 5 minutes. (Chart D 626.)

The hilum and lamellæ are not visible in many of the grains but in others the hilum is moderately distinct. A narrow and not very refractive band is formed about the margin of the grains before gelatinization. Gelatinization begins at the distal margin, as in *C. vestita* var. *rubro-oculata* and all the grains show some tendency for the process to begin at several disconnected points as in *C. rosea,* but in most of them this is confined to the distal margin or what is probably the distal margin. The progress of gelatinization in most of the grains is the same as that described in the second method under *C. vestita* var. *rubro-oculata,* and in the rest it is the same as that described under *C. rosea.* The gelatinized grains are large and very much distorted, and show but little resemblance to the form of the untreated grain. In this reaction the grains show qualitatively a closer relationship to *C. vestita* var. *rubro-oculata* than to *C. rosea.*

46. Starches of Calanthe vestita var. rubro-oculata, C. regnieri, and C. bryan.

C. vestita var. *rubro-oculata* (seed parent) is described on pages 772 to 775.

Starch of C. regnieri (Pollen Parent).

(Charts D 627 to D 634.)

Histologic Properties (See Foot-note, page 769).

In *form* most of the grains appear to be simple and isolated with the exception of rare aggregates consisting usually of 2 components. As the hilum is usually absent it is difficult to assert definitely that the grains are generally simple. Compound grains were not observed. Well-defined pressure facets are not present, probably due to the greatly compressed lateral surfaces, but occasionally a broadened or irregular concave distal end is noted, but is not nearly so clearly defined as in *C. vestita* var. *rubro-oculata.* The surface of the grain is generally irregular, much more irregular than in *C. vestita* var. *rubro-oculata.* In addition to the irregularities found in *C. vestita* var. *rubro-oculata* may be mentioned the following: either an entire or distal crenate margin and a small nipple-like protuberance at the proximal end. The conspicuous forms are nearly round, pure, and with narrow end, curved pyriform, and ellipsoidal. The additional forms are reniform, round, pure ovoid, ellipsoidal with squared or irregular distal end, imperfect rhomboidal, plano-convex often with rounded protuberances in center of plane surface, and grains of indefinite shape. The conspicuous forms of the separated grains are dome-shaped, often with irregular distal end, and broad pyriform. Most of the grains above enumerated have either a sinuous or crenate margin, the latter frequently more marked at or confined to one end. The majority are much broader and more flattened than in *C. vestita* var. *rubro-oculata,* and when viewed on edge they are usually narrow lenticular, narrow ellipsoidal, and rod-shaped. A few scattered grains are found which are larger than in *C. vestita* var. *rubro-oculata* and not much flattened.

The *hilum* is not usually demonstrable and when it can be seen is much less distinct than in *C. vestita* var. *rubro-oculata,* and is a small round, non-refractive spot. A delicate transverse fissure may be present at the hilum, and either 1 median or 2 longitudinal fissures emerge from the hilum and proceed distalwards. When 2 are present they may be directed obliquely towards the distal corners, but in narrower grains they often soon become so deflected as to be nearly parallel with one another; these fissures are usually non-refractive. Definite fissures connected with the hilum are less frequent than in *C. vestita* var. *rubro-oculata,* and when present lack the refractivity usually found in that species. The main body of most of the grains is composed of a refractive mass which is broken into fragments or large granules, either by a network of translucent lines or by translucent dots which impart a pitted appearance to this region of the grain; such grains were not found in *C. vestita* var. *rubro-oculata.* The position of the hilum varies from centric to quite eccentric; the range of eccentricity being 0.46 to 0.1, more frequently 0.25 of the longitudinal axis. Since the hilum is rarely demonstrable these figures must be considered provisional.

The *lamellæ* are not usually demonstrable, much less frequently than in *C. vestita* var. *rubro-oculata.* The surface of a few scattered smaller grains is homogeneously refractive, rarely with 1 distinct lamella near the hilum, and such grains closely resemble those commonly found in *C. vestita* var. *rubro-oculata.* In the main body of most of the grains no lamellæ are demonstrable, but this region is heterogeneously refractive as already described, and is bounded by a narrow very refractive marginal border which is frequently composed of but 1, rarely 2 or 3 lamellæ; in the more slender grains this border is generally lacking at the distal margin; such grains were not observed in *C. vestita* var. *rubro-oculata.* Since the lamellæ can not be counted throughout the grain, no number can be stated.

The *size* varies from the smaller grains, which are 10 by 6μ, to the larger, which are 36 by 34μ in length and breadth, commonly about 24 by 23μ in length and breadth. The grains are exceedingly light, which may explain the comparatively large size of the smaller grains, as the smallest have probably not been precipitated.

Polariscopic Properties.

The *figure* varies from centric to quite eccentric, but very few grains occur in which it is distinct, much fewer than in *C. vestita* var. *rubro-oculata.* When distinct the lines have the same arrangement and are as fine as in *C. vestita* var. *rubro-oculata.* The usual arrangement resembles a square or rectangular box, the corners of which are always pierced and sometimes the sides at one or more points. No clearly defined double and multiple figures are observed.

The *degree of polarization* is generally absent or very low in the mesial portion, simply present at the margin which is usually high (value 35). Rare grains occur in which polarization is distinct throughout, and varies from high to very high. The mean is much lower than in *C. vestita* var. *rubro-oculata.* A variation is also found in the same aspect of a grain as in *C. vestita* var. *rubro-oculata,* and also in the sides of the box arrangement mentioned under figure.

With *selenite* the entire quadrants are rarely observed; when present they vary as in *C. vestita* var. *rubro-*

oculata. The colors are generally impure, the impurity found at both ends of the scale much less frequently pure than in *C. vestita* var. *rubro-oculata.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains immediately color a moderately light violet which is a little lighter and redder than in *C. vestita* var. *rubro-oculata* (value 35); the color deepens quickly, becoming bluer in tint, but is neither so deep nor so blue as in *C. vestita* var. *rubro-oculata.* The color is somewhat uneven over the main body of the grain with the margin almost colorless in many; there is also considerable variation among the different grains, and it is greater than in *C. vestita* var. *rubro-oculata.* With 0.125 per cent Lugol's solution the grains immediately color a light violet, a little redder than in *C. vestita* var. *rubro-oculata,* which quickly becomes moderate to moderately deep, more uneven in depth with mean lighter and more reddish than in *C. vestita* var. *rubro-oculata.* After heating in water until the grains are gelatinized and then adding 2 per cent Lugol's solution, the gelatinized grains vary from a light violet to rare *grains* of deep blue with a reddish tint, the mean is lighter and redder than in *C. vestita* var. *rubro-oculata,* the *solution* is a moderate blue with greenish tint, lighter and greener than in *C. vestita* var. *rubro-oculata.* If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution, the scattered *grain-residues* color a light blue with reddish tint, about the same depth but more reddish than in *C. vestita* var. *rubro-oculata,* the *capsules* become a light brick-red to deep wine-red—more of a yellowish red than in *C. vestita* var. *rubro-oculata.* The *solution* is lighter and more greenish in tint than that of *C. vestita* var. *rubro-oculata.*

Aniline Reactions.

With *gentian violet* the grains color light to moderate at once, a little deeper with more variation in the different grains than in *C. vestita* var. *rubro-oculata.* In 30 minutes the grains become a light to moderately deep violet (value 50), being lighter and more of a bluish violet at the margin of round grains and at the distal margin of the more slender grains. The rare fissures color more of a rose-violet than the body of the grain. In half an hour there is greater variation in depth with the mean a little lighter than in *C. vestita* var. *rubro-oculata;* the rare fissures color more lightly, and there is more variation in depth between the body of the grain and the margin than in *C. vestita* var. *rubro-oculata.*

With *safranin* most of the grains immediately become moderate with occasional moderately deep, a little deeper at once than in *C. vestita* var. *rubro-oculata;* and in half an hour they deepen slightly, there being a larger number of the moderately deep than at once (value 60); the color is a little lighter and more of a yellowish red than in *C. vestita* var. *rubro-oculata.* The variation in depth in the same aspect of a given grain is the same as with gentian violet.

Temperature Reactions.

The majority of the grains are gelatinized at 70° to 72° C., and in all but rare resistant grains at 76° to 78° C., mean 77° C.

During the process of heat gelatinization, the outermost marginal lamella or lamellæ, which as in *C. vestita* var. *rubro-oculata,* are more resistant than the other parts of the grain, break into refractive segments. These segments may become concave and finally gelatinized, sometimes accompanied by a slit-like rupture of the capsule, but not with convoluted distortion as at the distal end of *C. vestita* var. *rubro-oculata.* An irregular frequently very abrupt series of either invagination or twisting changes may occur throughout the entire margin; when at but one end it appears as a deep invagination at what seems to be the proximal.

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 52 per cent of the entire number of grains and 67 per cent of the total starch in 5 minutes; in about 92 per cent of the grains and 95 per cent of the total starch in 15 minutes; in more than 99 per cent of the total starch in 30 minutes. (Chart D 627.)

The hilum unlike that in *C. vestita* var. *rubro-oculata* is not visible, except in a few grains where a bubble is seen, presumably at the hilum. Lamellæ also are not seen. A much smaller refractive band than in *C. vestita* var. *rubro-oculata* forms about the border of the more resistant grains and gradually grows somewhat broader. Gelatinization in some grains begins at the margin, and in the rest the interior is affected first, and is first separated into refractive granules and then gelatinized and the progress in the two methods is very different from anything noted in *C. vestita* var. *rubro-oculata.* In the first class of grains, the margin, or a certain part of the margin, becomes gelatinous with much sacculation and distortion of the capsule, and the interior of the grain becomes divided into refractive granules, which in turn becomes gelatinized. In the second class, the whole grain simply swells somewhat irregularly, as the granules become gelatinized. The gelatinized grains are moderately large with thin capsules and do not retain as much of the form of the untreated grain as in *C. vestita* var. *rubro-oculata.*

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 21 per cent of the entire number of grains and 75 per cent of the total starch in 5 minutes; in about 44 per cent of the grains and 90 per cent of the total starch in 15 minutes; in about 96 per cent of the grains and 99 per cent of the total starch in 30 minutes; in about 99 per cent of the grains and over 99 per cent of the total starch in 45 minutes; parts of rare grains remain ungelatinized in 60 minutes. (Chart D 628.)

The hilum is not demonstrable except in a few grains, and in these it becomes distinct. The lamellæ also are usually not demonstrable. Gelatinization begins in all parts of the interior of the grain. The process is very different from that observed in *C. vestita* var. *rubro-oculata.* The grain becomes more translucent and appears to be criss-crossed by a number of fine lines or fissures dividing the material into fine granules, and in many grains there are also broad cracks extending in various directions from margin to margin which divide this finely granular starch into various-sized pieces. Dissolution of the capsule occurs at several points, and as the interior part of the grain becomes gelatinous it flows out of these openings and is completely dissolved.

Shreds of the capsule often remain after the rest has dissolved. No true completely gelatinized grains are noted.

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in but rare grains, less than 0.5 per cent of the entire number, and 25 per cent of the total starch is gelatinized in 5 minutes; still but rare grains are completely gelatinized and 66 per cent of the total starch gelatinized in 30 minutes; complete gelatinization occurs in about 31 per cent of the grains and 93 per cent of the total starch in 30 minutes; in about 41 per cent of the grains and 96 per cent of the total starch in 45 minutes; in about 45 per cent of the grains and 98 per cent of the total starch in 60 minutes. (Chart D 629.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 56 per cent of the entire number of grains and 86 per cent of the total starch in 5 minutes; in about 63 per cent of the grains and 93 per cent of the total starch in 15 minutes; in about 70 per cent of the grains and 96 per cent of the total starch in 30 minutes; little if any further advance in 45 and 60 minutes, respectively. (Chart D 630.)

No bubble occurs at the hilum, and rarely definite fissures proceed from the hilum, such as found in *C. vestita* var. *rubro-oculata.* The granules in the mesial region are more refractive throughout the entire portion, gelatinization of them is more rapid towards the distal end of narrow or one side of rounded grains, but the group of larger refractive granules at the proximal end is not so marked as in *C. vestita* var. *rubro-oculata.* The marginal lamella or lamellæ of rounded grains and that at the proximal end and sides of slender grains break into very refractive linear granules, not commonly observed in *C. vestita* var. *rubro-oculata.* During gelatinization of this outermost layer, it may break into small segments and the process is always accompanied by much distortion. The gelatinized grains are swollen and much distorted, the latter more throughout the entire margin than in *C. vestita* var. *rubro-oculata.* A few refractive granules, segments, or a small concave area at one end, may remain in an otherwise gelatinized grain; this was not noted in *C. vestita* var. *rubro-oculata.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 86 per cent of the entire number of grains and 99 per cent of the total starch in 30 seconds; in about 98 per cent of the grains and more than 99 per cent of the total starch in 5 minutes. (Chart D 621.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 9 per cent of the entire number of grains and 42 per cent of the total starch in 5 minutes; in about 18 per cent of the grains and 71 per cent of the total starch in 15 minutes; in about 22 per cent of the grains and 89 per cent of the total starch in 30 minutes; in about 32 per cent of the grains and 92 per cent of the total starch in 45 minutes; in about 36 per cent of the grains and 94 per cent of the total starch in 60 minutes. (Chart D 632.)

Fissures similar in character to those in *C. vestita* var. *rubro-oculata* are formed which resemble this starch in contour and homogeneous refractivity; but later irregular deep fissures proceed over the mesial region of such grains more often than in *C. vestita* var. *rubro-oculata.* The characteristic grains of this species have either a sinuous or a crenate margin and appear unevenly refractive when viewed from above, due probably to unequal density caused by the margin; these grains are also broader than the characteristic ones of *C. vestita* var. *rubro-oculata.* Similar fissures form in these grains to those noted for *C. vestita* var. *rubro-oculata.* The border which is sharply defined by the formation of these fissures in both types of grains is much narrower than that found in *C. vestita* var. *rubro-oculata;* in the first-named grains the mesial region is broken into more refractive granules although in both types these are less resistant than in *C. vestita* var. *rubro-oculata.* At the completion of the experiment (60 minutes) more grains have undergone disintegration and solution and many more are in the act of breaking down than in *C. vestita* var. *rubro-oculata;* the narrow border is also quite resistant especially at the proximal end, though narrower and less resistant than in *C. vestita* var. *rubro-oculata.* Some grains become completely gelatinized without previous disintegration at one or more points, and are then much swollen and somewhat distorted. All the grains are swollen during the reaction as in *C. vestita* var. *rubro-oculata,* but more frequently show distortion and partial disintegration.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 5 per cent of the entire number of grains and 77 per cent of the total starch in 5 minutes; in about 6 per cent of the grains and 80 per cent of the total starch in 15 minutes; in about 10 per cent of the grains and 85 per cent of the total starch in 30 minutes; in about 19 per cent of the grains and 90 per cent of the total starch in 45 minutes; in about 19 per cent of the grains and 93 per cent of the total starch in 60 minutes. (Chart D 633.)

The hilum or lamellæ are not visible, except in a very few grains. Gelatinization begins all through the interior of the grains which is divided into very fine granules by many fine fissures, and part or all of the marginal material is often separated from the rest by an irregular fissure; the capsule, however, is not broken until later. As the granular starch gelatinizes the grain enlarges and there is here also more frequent dissolution of the capsule than in *C. vestita* var. *rubro-oculata.* The gelatinized grains are not so large as in *C. vestita* var. *rubro-oculata,* and are much more distorted.

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 92 per cent of the entire number of grains and 96 per cent of the total starch in 3 minutes; in more than 99 per cent of the grains and total starch in 5 minutes. (Chart D 634.)

The hilum and lamellæ are not visible. A very narrow and not very refractive band is formed about the margin before gelatinization begins. Gelatinization begins at one point on the margin and proceeds differently from the same reaction in *C. vestita* var. *rubro-oculata* by the invasion of the grain by large irregular fissures and cracks, which separate off small and large pieces of ungelatinized starch, which then gelatinize; when the end of the grains opposite to that at which gelatinization started is reached, the ungelatinized starch becomes very extensively fissured, and quickly and widely separated

into various sized pieces which are rapidly gelatinized. The gelatinized grains are large and very much distorted, and do not retain as much of the form of the untreated grain as do those of *C. vestita* var. *rubro-oculata*.

Calanthe bryan (Hybrid).

(Charts D 627 to D 634.)

Histologic Properties (See Foot-note, page 769).

In *form* most of the grains appear to be simple and isolated with the exception of a few which are found in aggregates, usually consisting of 2 components. Compound grains are rarely determined. Since a hilum is not usually demonstrable definite statements as to simple and compound grains are unsatisfactory. Well-defined pressure facets similar to those of *C. vestita* var. *rubro-oculata* are rarely observed, but are more frequent than in *C. regnieri*. The surface of the grain is frequently irregular, the irregularities being due to the same causes as those of both parents. The grains are more irregular than in *C. vestita* var. *rubro-oculata*, but not quite so irregular as in *C. regnieri*. The conspicuous forms are ellipsoidal, sometimes with squared or crenate distal end; potato-shaped; pyriform; reniform; nearly round; and plano-convex, often with rounded central protuberances on the plane surface. The additional forms are pure ovoid, pyriform with 1 end curved, round, shield-shaped, irregular rhomboidal, and grains of indefinite shape. The conspicuous separated grains are dome-shaped, bell-jar-shaped, and ovoid grains with a unilateral concave depression. Most of the grains mentioned have an undulating margin, and many have a crenate distal margin; this absence from the pure type is much more evident than in *C. vestita* var. *rubro-oculata*, but not so marked as in *C. regnieri*. The grains are much more varied in shape with a more even balance between slender and broadened types than in either parent. The grains vary from slightly to much flattened, the mean much more laterally compressed than those of *C. vestita* var. *rubro-oculata*, with the mean somewhat less flattened than in *C. regnieri*. When viewed on edge they are ovoid, narrow ellipsoidal, lenticular to rod-shaped, the more flattened types frequently exhibiting a median central line resembling a fissure. In form the majority of the grains are closer to those of *C. regnieri* and the minority to *C. vestita* var. *rubro-oculata*.

The *hilum* is not demonstrable in most grains, much less frequently than in *C. vestita* var. *rubro-oculata*, but in somewhat more grains than in *C. regnieri*. When demonstrable it is a small, non-refractive, round or lenticular spot; the latter may be directed longitudinally. Either a small rounded cavity or a short straight or crescentic transverse cleft is occasionally present at the hilum. Definite fissures leaving the hilum are less varied and usually lack the refractivity present in *C. vestita* var. *rubro-oculata*, but they are more frequent, varied, and usually more clearly defined than in *C. regnieri*. The majority of the grains are composed of refractive masses which are separated by translucent non-refractive lines, more frequently arranged as a median line with scattered lateral branches; in some grains these lines appear as a close network, or the refractive mass forming the body of the grain appears as though pitted by translucent dots; such grains are not observed in *C. vestita* var. *rubro-oculata*, and the former are much more frequent and the latter less frequent than in *C. regnieri*. The position of the hilum is centric to quite eccentric; the range of eccentricity varies from 0.33 to 0.11, commonly about 0.2 to 0.17, of the longitudinal axis. Since the hilum is frequently not demonstrable, these figures must be considered provisional. In the character and eccentricity of the hilum the grains of *C. bryan* are closer to those of *C. regnieri*.

The *lamellæ* are not usually demonstrable, less frequently than in *C. vestita* var. *rubro-oculata*, but somewhat more frequently than in *C. regnieri*. The surface in a moderate number of smaller grains is homogeneously refractive, not nearly so often as in *C. vestita* var. *rubro-oculata*, but yet considerably more frequently than in *C. regnieri*. In such grains 1 lamella may be distinct and located moderately near the margin, the marginal band thus separated from the main body of the grain being even more refractive than the main body of the grain, similar to that described for *C. vestita* var. *rubro-oculata*, but not *C. regnieri*. Rarely a few lamellæ may be distinct near the hilum, not quite so frequently as in *C. vestita* var. *rubro-oculata*, but more frequently than in *C. regnieri*. In the main body of the majority of grains no lamellæ are demonstrable, but this region is heterogeneously refractive, and is surrounded by a refractive border; the boundary between the main body and the border may be demarcated either by a refractive lamella or what appears to be a fissure; frequently no lamellæ are demonstrable in this border, but occasionally 2 or 3 are moderately distinct; such grains are not observed in *C. vestita* var. *rubro-oculata*, they are similar to those commonly found in the other parent, but there is either no border or it is usually broader if present than in that species. The lamellæ of the grains of *C. bryan* are usually not demonstrable as in the grains of *C. regnieri* and when they are seen they are usually closer to those of *C. vestita* var. *rubro-oculata*. Lamellæ throughout the entire grain can not be counted and hence no number can be given.

The *size* varies from the smaller, which are 7 by 6μ, to the larger, which are 48 by 24μ in length and breadth; commonly about 30 by 22μ in length and breadth. The grains of *C. bryan* are larger than either parent, but are closer to *C. regnieri* than to *C. vestita* var. *rubro-oculata*. In proportion of length to width they are closer to *C. vestita* var. *rubro-oculata*.

Polariscopic Properties.

The *figure* varies from centric to quite eccentric but is more frequently not distinct, much less often than in *C. vestita* var. *rubro-oculata*, but distinct in considerably more grains than in *C. regnieri*. When distinct throughout, the lines have the same character and arrangement as in both parents. The arrangement more frequently observed is the same as the minority in *C. vestita* var. *rubro-oculata* and as in most grains of *C. regnieri* the box is often rectangular, but it occurs with considerably less frequency and is less seldom pierced at the sides than in *C. regnieri*. Double and multiple figures are present, more numerous than in *C. vestita* var. *rubro-oculata* and these are not observed in the other parent.

The *degree of polarization* is more frequently absent or very low in the mesial portion, but in a moderate proportion of grains it is high to very high (value 45),

much lower than in *C. vestita* var. *rubro-oculata,* but considerably higher than in the other parent. There is a variation both in the sides of the box arrangement described under *figure* and in the grains with entire polarization as in both parents.

With *selenite* the entire quadrants are moderately often sharply defined, much less frequently than in *C. vestita* var. *rubro-oculata,* but considerably more often than in the other parent; when present, they vary as in both parents. The colors are more frequently impure, much less pure than in *C. vestita* var. *rubro-oculata,* but considerably more than in the other parent. The impurity is at both ends of the scale as in parents.

In degree of polarization, character of the figure, and appearance with selenite the grains of *C. bryan* are closer to those of *C. regnieri* than to *C. vestita* var. *rubro-oculata.*

Iodine Reactions.

With 0.25 per cent Lugol's solution the grains immediately color a moderate violet (value 38), almost as deep as in *C. vestita* var. *rubro-oculata,* and a little deeper than in the other parent; they deepen quickly, becoming bluer in tint with considerable variation in depth of the different grains; the main body of the grain is often deeper than the margin, which may be almost colorless. The grains become neither so deep nor so bluish in tint as in *C. vestita* var. *rubro-oculata,* and there is also a greater variation among the different grains and in the same aspect of a given grain than in *C. vestita* var. *rubro-oculata.* The grains deepen with about the same variation in the different grains, with slightly less in the same aspect of a given grain, and become a little more bluish in tint than in *C. vestita* var. *rubro-oculata.* With 0.125 per cent Lugol's solution the *grains* color a light violet which quickly deepens, becoming bluer in tint, the variations in the different grains and the same aspect of a given grain are about as above, the comparison with the parents is the same as with the 0.25 per cent Lugol's solution. After heating in water until the grains are gelatinized and then adding a 2 per cent Lugol's solution, the gelatinized *grains* become light to moderate blue with a very reddish tint; they are more reddish and lighter than those of *C. vestita* var. *rubro-oculata,* but are less reddish and there is less variation in depth with mean slightly deeper than in *C. regnieri.* The *solution* is a deep blue, deeper and less greenish in tint than in both parents. If the preparation is boiled for 2 minutes and then treated with an excess of 2 per cent Lugol's solution, the *grain-residues* color a light blue with reddish tint, about the same depth as in both parents, a little more reddish than in *C. vestita* var. *rubro-oculata,* but hardly so reddish as in *C. regnieri.* The *capsules* color a deep old-rose to either wine-red or a deep heliotrope. The color has a little more yellow in the red than in *C. vestita* var. *rubro-oculata,* but not nearly so yellowish as in *C. regnieri;* it is deeper than in both parents. The *solution* is a very deep blue, deeper than in both parents. In the qualitative reactions with iodine the grains of *C. bryan* are closer to those of *C. vestita* var. *rubro-oculata,* than to those of *C. regnieri.*

Aniline Reactions.

With *gentian violet* most of the grains color lightly, while a few become a moderate violet; more variation with the mean deeper than in *C. vestita* var. *rubro-oculata;* but there being less of the moderate, the mean is not as deep as in *C. regnieri.* In half an hour they become moderate to moderately deep (value 53), with a larger proportion of the former, the mean a little lighter than in *C. vestita* var. *rubro-oculata;* and less variation in depth with the mean deeper than in *C. regnieri.* The variation in depth of the main body and the margin in the same aspect of a given grain is much more frequent than in *C. vestita* var. *rubro-oculata,* but not so marked nor quite so frequent as in *C. regnieri.* The variation in depth of the rare fissures and body of the grain is less marked than in *C. vestita* var. *rubro-oculata,* but more than in *C. regnieri.*

With *safranin* most of the grains immediately become light to moderate; about the same depth as in *C. vestita* var. *rubro-oculata,* a little lighter than in *C. regnieri.* In half an hour they stain moderate to moderately deep (value 63); the variation in the depth of the same aspect of a given grain is the same as with gentian violet; a trifle lighter, than in *C. vestita* var. *rubro-oculata;* deeper and less of yellow in the red than in *C. regnieri.*

In the reactions with aniline stains the grains of *C. bryan* are slightly closer to *C. regnieri* than to *C. vestita* var. *rubro-oculata.*

Temperature Reactions.

The temperature of gelatinization for the majority of grains is at 72° to 74° C., and of all but rare resistant grains at 76° to 77.5° C., mean 76.7° C. At the beginning of heat gelatinization, the steps more closely resemble those of *C. regnieri,* but in the later stages the outermost lamellæ are gelatinized and become convoluted as in *C. vestita* var. *rubro-oculata,* so that the gelatinized grain closely resembles this species, instead of *C. regnieri.* The temperature of gelatinization of *C. bryan* is much closer to *C. regnieri* than to *C. vestita* var. *rubro-oculata.*

Effects of Various Reagents.

The reaction with *chloral hydrate* begins immediately. Complete gelatinization occurs in about 29 per cent of the entire number of grains and 61 per cent of the total starch in 5 minutes; in about 48 per cent of the grains and 75 per cent of the total starch in 15 minutes; in about 74 per cent of the grains and 89 per cent of the total starch in 30 minutes; in about 79 per cent of the grains and 91 per cent of the total starch in 45 minutes; in about 89 per cent of the grains and 94 per cent of the total starch in 60 minutes. (Chart D 627.)

The hilum becomes distinct in some of the grains and a bubble is frequently formed there, also deep fissures occur which during gelatinization divide the grain into several parts. The lamellæ become distinct in some of the grains as in *C. vestita* var. *rubro-oculata,* but in others there is no trace of either hilum or lamellæ, as they resemble the characteristic grains of *C. regnieri.* A narrow refractive band forms slowly about the margin of the grain and recedes as gelatinization advances from the margin, as in *C. vestita* var. *rubro-oculata.* Gelatinization begins in the interior of some of the grains as in *C. regnieri,* but in most at the margin, or at the margin and at the hilum as in *C. vestita* var. *rubro-oculata,* and the process is the same as in *C. vestita* var. *rubro-oculata.* The gelatinized grains have rather thin capsules, are

much enlarged, and somewhat distorted. In this reaction the grains of *C. bryan* show a closer relationship qualitatively to those of *C. vestita* var. *rubro-oculata* than to *C. regnieri.*

The reaction with *chromic acid* begins immediately. Complete gelatinization occurs in about 11 per cent of the entire number of grains and 40 per cent of the total starch in 5 minutes; in about 45 per cent of the grains and 85 per cent of the total starch in 15 minutes; in about 60 per cent of the grains and 93 per cent of the total starch in 30 minutes; in about 91 per cent of the grains and 99 per cent of the total starch in 45 minutes; in about 99 per cent of the grains and over 99 per cent of the total starch in 60 minutes. (Chart D 628.)

In those grains in which the hilum and lamellæ are demonstrable, they become as distinct as in *C. vestita* var. *rubro-oculata,* but usually the grains more closely resemble those of *C. regnieri* in appearance. Gelatinization begins at the hilum, or at some point similar to a hilum, and proceeds as in *C. vestita* var. *rubro-oculata* by the extension distally of fine branching fissures, which divide the material of the grain into fine granules. The border about the margin of the grain is more resistant as in *C. vestita* var. *rubro-oculata,* and remains after the rest of the grain has gelatinized, but differs from *C. vestita* var. *rubra-oculata* and resembles *C. regnieri* in being invaded by cracks at various points, at which the capsule is dissolved. Through these points the semi-fluid mass in the interior escapes and is dissolved. The few grains which attain complete gelatinization are the same in appearance as those of *C. vestita* var. *rubro-oculata.* In this reaction the grains of *C. bryan* are closer qualitatively to *C. vestita* var. *rubro-oculata.*

The reaction with *pyrogallic acid* begins in 1 minute. Complete gelatinization occurs in but rare grains and 15 per cent of the total starch in 5 minutes; still in but rare grains and 33 per cent of the total starch in 15 minutes; complete gelatinization occurs in about 25 per cent of the entire number of grains and 80 per cent of the total starch in 30 minutes; in about 32 per cent of the entire number of grains and 85 per cent of the total starch in 45 minutes; in about 40 per cent of the entire number of grains and 92 per cent of the total starch in 60 minutes. (Chart D 629.)

The reaction with *nitric acid* begins immediately. Complete gelatinization occurs in about 21 per cent of the entire number of grains and 62 per cent of the total starch in 5 minutes; in about 27 per cent of the grains and 75 per cent of the total starch in 15 minutes; in about 33 per cent of the grains and 81 per cent of the total starch in 30 minutes; in about 37 per cent of the grains and 88 per cent of the total starch in 45 minutes; in about 38 per cent of the grains and 89 per cent of the total starch in 60 minutes. (Chart D 630.)

A small transient bubble often occurs at the hilum, less frequently than in *C. vestita* var. *rubro-oculata,* but more frequently than in *C. regnieri;* definite fissures proceed from the hilum with much less frequency than in *C. vestita* var. *rubro-oculata,* but with more frequency than in *C. regnieri.* The granules throughout the entire mesial region are more refractive than in *C. vestita* var. *rubro-oculata,* but not quite so refractive as in *C. regnieri.* There is a tendency to definition of lamellæ in the mesial region between fissures, less distinct and much less frequent than in *C. vestita* var. *rubro-oculata;* but this was not observed in *C. regnieri.* During gelatinization, a mass of starch in the mesial region near the proximal end is sometimes more resistant than towards the distal end and breaks into a mass of larger refractive granules, found less commonly than in *C. vestita* var. *rubro-oculata;* but much more than in *C. regnieri.* The marginal lamellæ become sharply defined, striated, and may break into linear granules; the latter more commonly than in *C. vestita* var. *rubro-oculata;* about as in *C. regnieri.* This marginal layer is gelatinized with somewhat more distortion than in *C. vestita* var. *rubro-oculata,* but with less distortion and more completely than in *C. regnieri.* The gelatinized grains are swollen and much distorted, the latter more than in *C. vestita* var. *rubro-oculata,* but less distorted than in *C. regnieri* and the presence of refractive granules or segments is not observed as sometimes found in *C. regnieri.* In this reaction the grains of *C. bryan* are qualitatively slightly closer to *C. vestita* var. *rubro-oculata,* than to *C. regnieri.*

The reaction with *sulphuric acid* begins immediately. Complete gelatinization occurs in about 85 per cent of the entire number of grains and 97 per cent of the total starch in 3 minutes; in about 98 per cent of the grains and more than 99 per cent of the total starch in 5 minutes. (Chart D 631.)

The reaction with *hydrochloric acid* begins immediately. Complete gelatinization occurs in about 26 per cent of the entire number of grains and 58 per cent of the total starch in 5 minutes; in about 34 per cent of the grains and 74 per cent of the total starch in 15 minutes; in about 38 per cent of the grains and 92 per cent of the total starch in 30 minutes; in about 50 per cent of the grains and 94 per cent of the total starch in 45 minutes; in about 56 per cent of the grains and 96 per cent of the total starch in 60 minutes. (Chart D 632.)

Gelatinization is preceded and continues as in both parents, but there is much greater variation among the grains than in either parent. A number of medium-sized globular and ovoid grains are present which are very resistant and advance little beyond the swollen hilum and formation of deep fissures; these grains resemble those of *C. vestita* var. *rubro-ocutata* in form but are even more resistant than those grains. The majority of the grains, although at first more homogeneous in contour and refractivity, resemble more closely those of *C. regnieri* in form; in such grains gelatinization sometimes begins at the margin, often the corners limiting the distal end if the grain is somewhat triangular, accompanied by distention of the capsule at these points; this form of gelatinization was not noted in either parent. The fissures in the majority of grains form the boundary line between a narrower border and the mesial region than in *C. vestita* var. *rubro-oculata,* about the same as in *C. regnieri.* At the end of the experiment (60 minutes) the majority of grains are gelatinized and some have undergone entire solution or are in various stages of disintegration while in the minority there is either a broad refractive border bounding an irregular mass of refractive granules or these grains are almost unaffected—much greater variation than in either parent. While the narrow refractive border is less resistant than in both parents, causing a much greater gelatinization of the grains, yet the number of slightly or practically not

affected grains is so much greater than in *C. regnieri* that the total gelatinization is somewhat less than in this species. Gelatinized grains are swollen as in both parents but are more distorted. In this reaction the grains of *C. bryan* show, qualitatively, a closer resemblance to those of *C. regnieri* than to *C. vestita* var. *rubro-oculata*.

The reaction with *potassium hydroxide* begins immediately. Complete gelatinization occurs in about 6 per cent of the grains and 53 per cent of the total starch in 5 minutes; in about 10 per cent of the grains and 62 per cent of the total starch in 15 minutes; in about 16 per cent of the grains and 71 per cent of the total starch in 30 minutes; in about 21 per cent of the grains and 75 per cent of the total starch in 45 minutes; in about the same percentage of the grains and 77 per cent of the total starch in 60 minutes. (Chart D 633.)

The hilum is usually not visible as in *C. regnieri*, but in some grains it is distinct as in *C. vestita* var. *rubro-oculata*, and the lamellæ also are usually not visible but are sometimes distinct. Gelatinization begins in the interior and proceeds in the majority of grains as in *C. regnieri*, and in the minority as in *C. vestita* var. *rubro-oculata*. There are nearly as many grains dissolved as in *C. regnieri*. The gelatinized grains are larger and not so much distorted as in *C. regnieri* but not so large and much more distorted than in *C. vestita* var. *rubro-oculata*. In this reaction the grains of *C. bryan* are closer qualitatively to those of *C. regnieri* than to *C. vestita* var. *rubro-oculata*.

The reaction with *sodium salicylate* begins immediately. Complete gelatinization occurs in about 43 per cent of the entire number of grains and 53 per cent of the total starch in 5 minutes; in about 98 per cent of the grains and 99 per cent of the total starch in 15 minutes. (Chart D 634.)

The hilum in the grains resembling those of *C. vestita* var. *rubro-oculata* is moderately distinct and a small bubble is formed there as in the grains of that starch. The lamellæ are not visible. A narrow and not very refractive band is formed as in the parents about the margin of the grains before gelatinization begins. Gelatinization begins at the margin in every grain and at the distal margin of those grains in which the hilum is visible, and while most of the grains are very like those of *C. regnieri* in form the method of gelatinization is very like that described as the second method under *C. vestita* var. *rubro-oculata*. In the smaller number of grains which resemble *C. vestita* var. *rubro-oculata* in form the method of gelatinization is like the first method described under that starch. The gelatinized grains are large and very much distorted; they show less of the form of the untreated grain that those of *C. vestita* var. *rubro-oculata*. In this reaction, the grains show qualitatively a closer relationship to *C. vestita* var. *rubro-oculata* than to *C. regnieri*.

CHAPTER IX.

MACROSCOPIC AND MICROSCOPIC CHARACTERS OF PARENT-STOCKS AND HYBRID-STOCKS.

The laboratory records of the macroscopic and microscopic properties of seven sets of parent-stocks and hybrid-stocks compose this chapter. The more important data have been summarized and carried over into Part I, Chapter V, second and third sections of each parent-hybrid set.

All of these records were made by Miss Margaret Henderson, B.S., M.A. (University of Pennsylvania), who devoted one and a half years of painstaking care to this very tedious work.

In the pursuit of this investigation the precautionary measures set forth by Macfarlane, and quoted in full in Part I, Chapter I, pages 4 to 7, were very carefully observed, excepting in regard to the selection of the plants that are of the same types as those of the parents and the hybrids. It was not only impossible in this research to obtain the actual parents and hybrid, but also to select from the parent-stocks and hybrid-stocks specimens that correspond to the original types—the latter not being known even to the growers themselves, or having been placed on record. It was therefore necessary to select specimens that represent as closely as possible the assumed average type in each case. The plants were also selected with care as to age, and each of the several sets of orchids were kept under the same conditions as regards soil, temperature, moisture, and light in the orchid house of the Botanical Department of the University of Pennsylvania. It was contemplated at the inception of this research to include representatives of a number of genera, and material was obtained in the form of irids, narcissi, lilies, begonias, etc., but circumstances arose that necessitated the limitation of this part of the research. Moreover, it was contemplated to study coincidently both plant and starch characters, but conditions caused the abandonment of this project, excepting in the case of *Cymbidium* and *Miltonia*.

The microscopic sections were mounted in either water or acetic acid, the same medium being used for the sections of each set of parent-stocks and hybrid-stocks; or, when the sections were to be stained, immersion was always made for the same length of time, and then the specimens mounted in the same medium.

All of the macroscopic records given are averages of variable numbers of observations, the number depending upon the amount of available material. All of the microscopic records are averages, in each case of not less than 25 measurements. The magnification was varied to suit conditions, as is noted here and there in the text; but it was always the same when examining specimens of a given kind from any given set of parent-stocks and hybrid-stock.

Unfortunately, through an oversight, many characters that appeared to be exactly, or practically exactly, the same in both parent-stocks and hybrid-stocks were disregarded in the records. Obviously, had these been included, the figures of the summaries would have been modified, although not to any important degree, at least, in so far as modifying the principles set forth is concerned.

In the summaries at the ends of the several sections the signs, ♀, ♂, and ♀ = ♂, mean nearer to the seed parent, nearer to the pollen parent, and as near to one as to the other parent, respectively.

1. Macroscopic and Microscopic Characters of Ipomœa coccinea, I. quamoclit, and I. sloteri.

(Plates 25 to 29, figs. 145 to 177. Tables J, 1 to 10; and I, 1 and Summaries. Chart F 1.)

General Descriptions.

Ipomœa coccinea Linn. (*Quamoclit coccinea* Mœnch.) (seed parent) is described by House (Bull. Torrey Botanical Club, 1909 xxxvi, 599) as follows:

"Annual, climbing, glabrous; stems several meters long; leaf blades ovate, 3 to 10 cm. long, cordate, acute or acuminate at the apex, usually thin and submembranaceous, pale beneath, entire or somewhat hastate or angularly lobed; petioles as long as the blades or shorter: peduncles about equaling the leaves or longer, few-flowered or sometimes many-flowered; sepals oblong, 4 to 6 mm. long, the outer ones with subulate, infraterminal awns 2 to 5 mm. long; corolla scarlet, white or orange [orange-flowered form studied], the tube 3 to 4 cm. long, slightly enlarged above, the shallowly cup-shaped limb 1.5 to 2 cm. broad, 5-angled; capsules globose, 6 to 7 mm. high.

Distribution: Type locality: St. Domingo. Circumtropical. In America north to Florida, Texas, and Arizona. Extended as an escape from cultivation to Pennsylvania, Ohio, Missouri, and Arkansas."

Ipomœa quamoclit Linn (*Quamoclit quamoclit* Britton, *Q. vulgaris* Choisy, *Q. pinnata* Desr.) (pollen parent) is described by House (*loc. cit.*):

"Stems several meters long, glabrous: leaf-blades 2 to 10 cm. long, the pinnate segments narrowly linear: petioles shorter than the blades with numerous short leafy branches in their axils appearing stipule-like: peduncles commonly longer than the leaves: pedicels 25 to 30 mm. long, thickened and fleshy at least in the fruit: sepals oblong, obtuse, mucronate, 3 to 5 mm. long: corolla scarlet or white [scarlet-flowered form studied], 25 to 35 mm. long, the tube clavate, the limb nearly flat, the short ovate lobes acute: capsules ovoid, 4-celled, 8 to 10 mm. high.

"Type locality: India.

"Distribution: Circumtropical and extended by cultivation and as an escape through the southern United States, north to Virginia and Kansas."

With *Ipomœa sloteri* Macfarlane (hybrid), the vine is more vigorous than that of either parent; stem climbing branching, several meters long; leaf blades, dark green, wider and firmer, 5 to 6 cm. long, deeply lobed: petioles shorter than the blade: peduncles longer than the leaves, 2 to 5-flowered, flowers very numerous, pedicles slightly

thicker than the peduncles: sepals oblong, 7 mm. long, appressed to the tips with subulate infraterminal awns smaller than in *I. coccinea:* corolla scarlet; tube 3 cm. long, slightly enlarged above, shallow saucer-shaped limb 2 to 3 cm. broad, 5-angled: capsules ovoid, only a few mature: seeds 1 to 2 in each capsule, very rarely 3 to 4 mature.

Origin of I. sloteri.

A hybrid of *I. coccinea* and *I. quamoclit* was obtained in 1897 by hand pollination by Mr. Logan Sloter, who supplied the following data:

"This vine was in degree of growth and vigor in no way superior to its parents, if anything it was inferior to them. Foliage long and narrow, pale green, and thin of texture; flowers rotund and freely produced, but of a dull red hue and but three-quarters inch in diameter. This specimen was absolutely seedless. By repeating the original cross, I succeeded in producing a few specimens of it up till 1908, with the same result. But in 1908, one specimen produced one seed. This one seed was planted in 1909, and from it grew the *cardinal climber* as it appears to-day."

Mr. Sloter tried in hundreds of instances to cross this hybrid with other Ipomœas, but without success, nor could he succeed in crossing it with either of its parents. Therefore, he believes that the plants used in this research are first hybrids, the straight descendants from that one seed planted in 1909. He states:

"The *cardinal climber* is remarkably true from seed, the deviations being small and few, and so nearly identical with the parent as to be unnoticeable by the ordinary observer. For the most part they consist of some specimens showing small oculations or lighter places in the throat or opening of the tube, while others show no such markings. Some plants may be a shade lighter or a shade darker in color than others. Aside from this the *cardinal climber* has thrown off one specimen bearing dark rose flowers and a specimen bearing orange-scarlet flowers which come true from seed; also *Ipomœa serratifolia*, a leaf variant, thrown off by the parent plant three seasons ago (1910). *I. serratifolia* is identical with the *cardinal climber* in every respect except foliage. Its foliage has more the appearance of an uncut leaf with a toothed edge."

Examinations of three plants of the *cardinal climber* of the season of 1913, and eight plants of the season of 1914, all germinated from self-pollinated seed and grown in the Botanical Gardens of the University of Pennsylvania, showed that all were exactly alike, there being no appreciable variation.

Ipomœa sloteri has recently been described by Nieuwland (American Midland Naturalist, 1915, iv, 71). He goes on to state:

"Since the plant *Quamoclit sloteri* possesses characters that are notable enough to make it seem specifically distinct from either parent and from all of the members of the genus, why should the knowledge of its ancestry militate against it as deserving a 'species' name in binary nomenclature? With its character of breeding true it deserves to be ranked as a new plant as truly as the mutants or new species published under *Oenothera* during the last decade. It is likely that many species, unequivocably ranked as such found in the field, have fewer characters of distinction than the plant in question."

In reading over a description of *Quamoclit mullifida* Raf., Nieuwland "was forcibly struck by the fact that the characterization of this plant is practically identical with that of the plant produced by Mr. Sloter."

The following description is quoted from Rafinesque (New Flora of North America, 1836, Part IV, 57):

"*Quamoclit multifida* Raf. Twining, smooth, leaves multifid, lacinate, base truncate, sinuses obtuse, segments linear and lanceolate acute, peduncles 3–5 flors, equal to petioles, calix acute—a curious sp. deemed a garden hybrid produced by *Q. coccinea* and *Q. pinnata*, leaves variously cut few alike, some reniform with shorter cuts, flowers handsome, large purple, tube clavate, limb flat stellate pentagone, stamens exserted. Seen alive in gardens, where sometimes spontaneous. The *Q. pinnata* Raf. above is certainly *Ipomœa quamoclit* Linn, the only pinnate leaved *Quamoclit* known by him at the time."

It should be noted that Nieuwland erroneously states that the color of the flower of *I. sloteri* is the same as that of *I. coccinea*.

Comparisons of the Macroscopic Characters.

Cotyledons.

The *cotyledons* of *I. coccinea, I. quamoclit,* and *I. sloteri,* from seedlings of exactly the same age, are illustrated in Plate 25, figs. 145, 148, 151. The *hybrid* shows a mid-degree of intermediateness in the *shape* of the *cotyledons,* and it is also very nearly mid-intermediate in the *length* of the *mid-rib* and in the *length* of the *petiole.* (Table J 1.)

Table J 1.—*Lengths of midrib and petiole.*

Midrib:	I. coccinea 1.3 cm.;	I. quamoclit 0.3 cm.;	I. sloteri 0.9 cm.
Petiole:	I. coccinea 3 cm.;	I. quamoclit 1.05 cm.;	I. sloteri 2.3 cm.

The *cotyledons* of *I. coccinea* have two blunt, rounded lobes, with an angle of 90° between them; those of *I. quamoclit* have two narrow, tapering lobes, with an angle of 150°; those of the *hybrid* have two lobes which are slightly narrower than those of *I. coccinea* but much wider than those of *I. quamoclit,* and with an angle of 120°. The lobes of the *hybrid* taper more toward the apices than those of *I. coccinea,* but the apices are less acute than those of *I. quamoclit.*

Roots.

The *primary root* of *I. coccinea* is rather thick, has a diameter of 5 mm., is slightly flattened, and extends for a distance of about 7 cm. below the surface before dividing into two strong branches, before which division only a few small side rootlets are given off. The primary root of *I. quamoclit* is about 2.5 mm. in diameter, very slightly flattened, very long (19 cm.), and gives off only a few thread-like side rootlets. The rootage of the *hybrid* is much more extensive than in *either parent.* The primary root is thick, 10 mm. in diameter, and extends below the surface for a distance of 8 cm. before it divides into 2 or 3 strong branches. Above the point of division lateral rootlets arise which are long and branching and spread out a good distance just below the surface of the soil.

Stem.

The *stems* of all three plants are slender, climbing, and give off many branches. The stem of the *hybrid* has a greater diameter, attains a greater growth, and gives off many more branches than in *either parent,* in these respects being nearer to *I. coccinea* than to the other parent. The stems are in all cases flattened, one diameter being about half that of the other.

The diameters of the stem for *I. coccinea* are 5 by 2.5 mm.; for *I. quamoclit* 1.3 by 0.9 mm.; for *I. sloteri* 8.7 by 4.6 mm.

The stems of the parents and the hybrid branch at different distances above the ground: *I. coccinea* branches nearest the ground—4.2 cm.; *I. quamoclit,* a good distance above—7.1 cm.; and the *hybrid,* at a point between the two—6 cm.

Leaf.

A comparison of the lateral branches of the parents and hybrid (Plate 25, figs. 146, 149, 152) arising from the axil of a leaf on the main stem show that the branch of the *hybrid* is of greater length and more leafy than that of *either parent*. *I. coccinea* has large, thin, cordate leaves, somewhat hastate at the base; the lamina 6 by 5.4 cm.; the petiole 4.3 cm. long. *I. quamoclit* has thin pinnate leaves, the pinnæ thread-like—27 lobes, the lamina 4.8 by 5.1 cm.; the petiole 3.1 cm. long. The *hybrid* has deeply lobed, wider leaves, which are much firmer in texture than those of *either parent*—9 lobes; the lamina 5.6 by 7.3 cm.; the petiole 3.9 cm. Thus, though the *hybrid* is fairly mid-intermediate in shape, length of the lamina, and length of the petiole, the lamina is wider and the texture is firmer than in *either parent* and there are also marked protuberances at the base of the petiole. The leaves of the *hybrid* remain green longer and are more resistant to the attacks of insects than those of *I. coccinea* and *I. quamoclit*. By the beginning of October all of the leaves of *I. coccinea* have fallen, except a few on the short flowering branches. The older leaves of *I. quamoclit* have withered and only those on the newest branches have remained green. At the same time all the leaves on the *hybrid* are green, only a very few showing any trace of brownish-red.

Flower.

Flowers are borne in dichasial cymes: In *I. coccinea*, 7-flowered; in *I. quamoclit*, 1- to 2-flowered; and in the *hybrid*, 2- to 5-flowered. The peduncle in *I. coccinea* is thicker than the pedicle, much thinner in *I. quamoclit*, and only very slightly thinner in the *hybrid*. There are many more flowers produced on the *hybrid* than on *either parent*. The flowers of the *parents* and the *hybrid*, natural size, are illustrated in Plate 25, figs. 147, 150, and 153. (Table J 2.)

Table J 2.—*Sizes and colors of flower-parts.*

I. coccinea: Flower-stalk 6.1 cm.; salver tube 2 cm.; diameter of corolla limb 1.6 cm.; diameter of tube opening 0.3 cm.
- Color of outer tube yellow-orange to orange-red.
- Color of upper surface of corolla limb vermillion with yellow center.
- Shape of corolla limb, 5-rounded lobes.
- Calyx, length of awns, 3 to 4 mm.
- Stamens: Length of filaments 2.4 cm.; color of filaments white; color of anthers greenish-white.

I. quamoclit: Flower-stalk 2.6 cm.; salver tuber 2.6 cm., diameter of corolla limb 1.6 cm.; diameter of tube opening 0.4 cm.
- Color of outer tube reddish-pink.
- Color of upper surface of corolla limb crimson.
- Corolla limb-shape, 5-pointed star.
- Calyx, not awned.
- Stamens: Length of filaments 2.4 cm.; color of filaments pink near base becoming deep crimson at top; color of anthers crimson.

I. sloteri: Flower-stalk 8.8 cm.; salver tube 3 cm.; diameter of corolla limb 2.8 cm.; diameter of tube opening 0.5 cm.
- Color of outer tube vermillion-red.
- Color of upper surface of corolla limb scarlet.
- Shape of corolla limb, 5-pointed, almost hexagonal.
- Calyx, short awns, 2 mm.
- Stamens: Length of filaments 3.4 cm.; color of filaments white at base becoming scarlet-pink at top; color of anthers pale pink.

Though the flower in the *hybrid* is much *larger* than in *either parent*, it is of a mid-degree of intermediateness in the *shape* of the *corolla limb*, in the *shape* of the *sepals*, and in the *color* of the *corolla* and *stamens*.

Fruit.

The fruit is a capsule, many of which mature on one flower stalk in *I. coccinea;* usually only 1 (very rarely 2) matures in *I. quamoclit;* and usually 1 (very rarely 2) matures in the *hybrid*. The *capsule* is subglobose in *I. coccinea*, 7 by 9 mm.; ovate in *I. quamoclit*, 9 by 7 mm.; and very broadly ovate in the *hybrid*, 8 by 6 mm. The *number of seeds* matured in a capsule in *I. coccinea* is usually 4, rarely 2 or 1; in *I. quamoclit* usually 2, sometimes 3, more rarely 4 or 1; in the *hybrid* usually 1, very rarely 2 or 3.

The seeds of the *hybrid* are intermediate in length or height, but wider than in *either parent*, the greater width probably being due to the absence of crowding in the capsule. The seeds measure 3 by 3 mm. in *I. coccinea;* 5 by 2 mm. in *I. quamoclit;* and 4.5 by 3.5 mm. in the *hybrid*.

Although many more flowers are produced by the *hybrid* than by *either parent*, a smaller percentage of them in the *hybrid* develop fruit than in *either parent;* and a very small proportion of the seeds of the *hybrid* germinate.

Comparisons of the Microscopic Characters.

Cotyledons.

The cells, glands, and stomata of the epidermis of the cotyledons are exactly like those of the leaf, and they are described under the heading, "Mature leaf," page 789. Examinations were made with a Bausch and Lomb 2 in. ocular and 4 mm. objective; magnification 205 diameters. (Table J 3.)

Table J 3.—*Cells, glands, and stomata of cotyledons.*

Upper epidermis:
- *I. coccinea:* Cell walls wavy; cells 83.5 by 48μ; 1 gland in 5 fields; size of glands 38μ; 6.6 stomata in a field; size of stomata 38μ.
- *I. quamoclit:* Cell walls not so wavy as in I. coccinea; cells 74.5 by 49.5μ; 1 gland in 10 fields; size of glands 34.5μ; 9.4 stomata in a field; size of stomata 33.5μ.
- *I. sloteri:* Cell walls between the parents in waviness; cells 95.5 by 61.5μ; 1 gland in 8 fields; size of glands 40.5μ; 5.7 stomata in a field; size of stomata 49μ.

Lower epidermis:
- *I. coccinea:* Cell walls not as wavy as in I. quamoclit; cells 77.5 by 36μ; 1 gland in 4 fields; size of glands 35μ; 15.8 stomata in a field; size of stomata 34.2μ.
- *I. quamoclit:* Cell walls very wavy; cells 69 by 36μ; 2 glands in 1 field; size of glands 30.5μ; 13.7 stomata in a field; size of stomata 33.8μ.
- *I. sloteri:* Cell walls between the parents in waviness; cells 92 by 50.5μ; 1 gland in 2 fields; size of glands 39μ; 7.4 stomata in a field; size of stomata 47.5μ.

In the *hybrid* the cell walls are intermediate in waviness, and the number of glands present is intermediate between those of the *parents;* but the stomata are less numerous and larger, and the glands and cells are larger, than in *either parent*.

Roots.

Transverse sections of the roots of *I. coccinea*, *I. quamoclit*, and *I. sloteri* were taken at regions of the same age. In the three the epidermis had been entirely removed by sloughing.

There have been developed 3 *cork layers* in *I. coccinea;* 3 to 4 in *I. quamoclit;* and 3 in the *hybrid*. The cork cells of the *hybrid* are much larger than in *either parent*. (Table J 4.)

The *cork cells,* the *cambial cells,* and the thin-walled, rectangular *cortex cells* are larger in the *hybrid* than in *either parent.* (Table J 4.)

TABLE J 4.—*Size of cork cells, cork cambial cells, and cortex cells.*

Size.	I. coccinea.	I. quamoclit.	I. sloteri.
Cork cells	39.5 by 18	32.5 by 18	57.5 by 25
Cambial cells	29 by 11	43 by 18	61 by 39.5
Cortex cells	47 by 36	58 by 29	79 by 40

There may be present in a section of the cortex in *I. coccinea* 3 to 4 sclerenchymatous patches. Such patches are not seen in *I. quamoclit,* but there may be 1, never more, in the *hybrid.*

No definite dividing line exists between the cortex and the vascular cylinder.

Pitted vessels in the wood are often grouped together in twos, threes, and fives in *I. coccinea;* sometimes in twos in *I. quamoclit;* and often in twos and threes in the *hybrid,* but not so much grouping as in *I. coccinea,* yet more than in *I. quamoclit.*

The largest *vasa* in *I. coccinea* are in a zone a short distance interior to the outer layer of wood; in *I. quamoclit* at the exterior of the wood; and in the *hybrid* in a zone that is nearer the exterior than in *I. coccinea,* but nearer the interior than in *I. quamoclit,* that is, in a mid-intermediate position.

The diameters of the pitted vessels are: *I. coccinea* 104.5μ, *I. quamoclit* 75 5μ, *I. sloteri* 97μ. The diameters of largest pitted vessels are: *I. coccinea* 169μ, *I. quamoclit* 126μ, *I. sloteri* 169μ.

The cylinder is broken up by 4 rather wide medullary rays into 4 wedges in *I. coccinea;* the 4 rays are narrower and less distinct in *I. quamoclit;* and they are not quite so distinct in the *hybrid* as in *I. coccinea,* yet more distinct than in *I. quamoclit.* The width in the *hybrid* is intermediate.

No pith is present, a tetrarch protoxylem takes up the center of the cylinder.

STEM.

Transverse sections of the stems of *I. coccinea, I. quamoclit,* and *I. sloteri* were taken just below the first branch.

The *epidermis* is, in all 3, a layer of cells of the same *depth,* but in the *hybrid* the cells are of a greater *width* than in *either parent.*

The widths of the cells of the epidermis are: *I. coccinea* 29μ, *I. quamoclit* 22μ, *I. sloteri* 43μ.

Cuticle is developed on the outer walls. In the *hybrid* the epidermis appears rather indistinct and in places it has fallen off, due probably to the greater development of *cork* in the *hybrid,* there being 2 layers in it, and but 1 in *each parent.* The *cork cambial cells* of the *hybrid* are larger than in *either parent.*

The sizes of the cork cambial cells are: *I. coccinea* 36 by 7.2μ, *I. quamoclit* 18 by 7.2μ, *I. sloteri* 40 by 15μ.

The *cortex* consists of a cylinder of rounded cells, the smaller cells toward the exterior. A complete *cortical cylinder* of 2 to 3 layers, this number being increased to 6 in the region of least development of wood, is found in *I. coccinea;* there being 2 to 3 cortical layers in *I. quamoclit* and 5 layers in the *hybrid.*

The *endodermis* is very distinct and well defined in *I. coccinea,* but not so well defined in *I. quamoclit* and the *hybrid.* In the *hybrid,* however, the cells are much larger in both dimensions than in *either parent.*

The sizes of the endodermal cells are: *I. coccinea* 54 by 22μ, *I. quamoclit* 50 by 11μ, *I. sloteri* 90 by 36μ.

The outermost layer of *phloem* has some of its cells *sclerosed.* At the junction of each 2 endodermal cells there is at least 1 sclerosed cell. In *I. coccinea,* in a few places, there may be 2, 3, or up to 7, of these cells joined together. In *I. quamoclit* there is almost a continuous ring of such cells inside of the epidermis—one reason for which arrangement is that the endodermal cells are shorter than those in *I. coccinea,* thus bringing the sclerosed cells at the junctions nearer to each other; another reason is that some cells between those at the junctions have also become sclerosed. In the *hybrid* there are either 1 or 2 sclerosed cells at each junction of 2 endodermal cells, but they appear much farther apart and much less numerous than in *either parent* on account of the much greater length of the endodermal cells. The *sclerosed cells* in the *hybrid* are intermediate in size between those of the two parents, but slightly nearer those of *I. coccinea.*

The diameters of the sclerosed cells are: *I. coccinea* 29μ, *I. quamoclit* 18μ, *I. sloteri* 25μ.

The *phloem,* which is composed of sieve tubes, phloem cells, secretory cells, and chambered crystal cells, is in *both parents* less developed on the two sides where there is also less development of the wood, but in the *hybrid* is evenly developed on all sides. The *secretory* cells in *I. quamoclit* are the most numerous, there being on the average of 2 to each microscopic field, while in *I. coccinea* and the *hybrid* there is an average of 1. The *phloem* of the *hybrid* contains more *chambered crystal cells* than in *either parent.*

The numbers of *chambered crystal cells* are: *I. coccinea* 14, *I. quamoclit* 1 in 2 fields, *I. sloteri* 16.

The *wood cylinder* in the stems of all three plants consists of an innermost circle of primary bundles, and an outer continuous zone of wood cells and fibers. There is an irregular development of wood due to the flattening of the stem. In *I. quamoclit,* on the 2 narrow sides, there is no secondary wood, while in *I. coccinea* and the *hybrid* there is, but the cell walls have not become thickened. The other two sides have a much greater development of secondary wood with thickened cell walls. The development of wood in the *hybrid* is much greater than in *either parent.*

In the *hybrid,* just outside the phloem, between it and the endodermis, are *extra bundles* with xylem in the center surrounded by a zone of phloem. Transverse sections of the stem taken below the first and second branches have these bundles present, but sections below the third branch do not.

The largest *vasa* in the stem are larger in the *hybrid* than in *either parent*—in *I. coccinea* 180μ in diameter, in *I. quamoclit* 144μ, in *I. sloteri* 216μ.

There are 9 *protoxylem patches* in *I. coccinea,* each having on its inner side a small patch of intraxylary phloem which contains a very few crystal cells. There are many protoxylem patches and intraxylary phloem patches with many crystal cells in *I. quamoclit,* forming an almost complete zone. There are only 4 distinct

and well-developed protoxylem patches in the *hybrid.* They have a rather large area of intraxylary phloem on their inner faces. Crystal cells are present, but not as many as in *I. quamoclit.*

The *pith* in the three plants is composed of large rounded cells—the larger ones toward the center and the smaller ones toward the exterior.

Mature Leaf.

The Lamina.—The *epidermal cells* of the lamina are rather wavy-walled, and the cuticle is thin and striated. The cells become somewhat elongate along the veins, at which position and at the margins parts of the cells protrude, forming papillæ. At points where glands arise the cells become elongate, forming a star-like arrangement at the bases of the glands.

The glands are each composed of a small stalk cell and a capitate cell that is divided by radial walls, vertical to the surface on the leaf, and forming 8, 10, or 12 sectors. They are rich in protoplasm and stain readily.

The stomata, which are present on both surfaces of the leaf, are each composed of two guard cells, outside of which are two subsidiary cells parallel to the slit of the stomata.

Hairs are absent in *I. coccinea.* They are borne on larger, conical, basal cells, and are short, stiff, and dagger-like in *I. quamoclit.* They are much longer, less numerous, and do not appear to be so stiff in the *hybrid.* (Table J 5.)

Portions of the *upper epidermis* at the *base* of the lamina were examined under a Leitz No. 2 ocular and No. 6 objective.

The statistics of stomata, glands, cell walls, hairs, papillæ, and marginal cells at the base are shown in Table J 5.

Table J 5.

I. coccinea: Average number of stomata in a field 15, average number of glands in a field 1 in 3, diameter of glands 43μ, cell walls straight, hairs absent, length of hair papillæ along veins 39μ, protrusion of marginal cells 22μ, length of cells 60.2μ, width 34.4μ.

I. quamoclit: Average number of stomata in a field 8, average number of glands in a field 2 to 3, diameter of glands 35μ, cell walls wavy, length of hairs 120μ, stiff, length of hair papillæ along veins 17μ, length of cells 55.9μ, width 34.4μ.

I. sloteri: Average number of stomata in a field 12, average number of glands in a field 1, diameter of glands 52μ, cell-walls intermediate in character between those of parents, length of hairs 538μ, less numerous and less stiff, length of hair papillæ along veins 30μ, protrusion of marginal cells 15μ, length of cells 64.5μ, width 34.4μ.

The *stomata* and *glands* are nearly evenly distributed over the lamina in *I. coccinea,* but they are clustered near the veins in *I. quamoclit.* They are more evenly distributed in the *hybrid,* but somewhat more numerous near the veins.

In the *hybrid* the number of stomata, number of glands, waviness of the cell walls, length of the papillæ along the veins, and the amount of protrusion of marginal cells are between those of the corresponding values in the *parents,* but the stomata, cells, glands, and hairs of the *hybrid* are larger than in *either parent.* These characters are illustrated in Plates 26 and 27, figs. 154, 155, 156, 157, 158, 159, 160, 161, and 162. (Table J 6.)

In the *hybrid* the hairs here also are longer and the glands larger than in *either parent,* and in addition the hair papillæ along the veins are longer than *either parent.*

Portions of the upper epidermis near the apex and of the *lower epidermis* at the *base* of the lamina show, under the same magnification, the data given in Table J 6:

Table J 6.—*Stomata, glands, hairs, and cells of epidermis.*

Upper, near the apex:

- *I. coccinea:* Average number of stomata in field 11; average number of glands 1 in 2 fields; diameter of glands 34μ; hairs absent; length of hair papillæ along veins 13μ; length of cells 55.9μ; width of cells 30.1μ.
- *I. quamoclit:* Average number of stomata in a field 8, average number of glands 2, diameter of glands 30μ, length of hairs 116μ, length of hair papillæ along veins 13μ, length of cells 60.2μ, width of cells 30.1μ.
- *I. sloteri:* Average number of stomata in a field 10, average number of glands 4 in 5 fields, diameter of glands 43μ, length of hairs 353μ, length of hair papillæ along veins 21.5μ, length of cells 60.2μ, width of cells 38.7μ.

Lower, at the base:

- *I. coccinea:* Average number of stomata in a field 26, average number of glands 1, diameter of glands 34.4μ, length of cells 64.5μ, width of cells 38.7μ.
- *I. quamoclit:* Average number of stomata in a field 33, average number of glands 1 in 3 fields, diameter of glands 30.1μ, length of cells 51.6μ, width of cells 30.1μ.
- *I. sloteri:* Average number of stomata in a field 19, average number of glands 1 in 2 fields, diameter of glands 47.3μ, length of cells 77.4μ, width of cells 38.7μ.

In the *hybrid* the stomata are larger but less numerous, and the cells and glands are larger than in *either parent.*

The *lower epidermis* of the lamina *near the apex* shows, under the same magnification, the characters given in Table J 7:

Table J 7.—*Stomata, glands, and cells of lower epidermis near apex.*

I. coccinea: Average number of stomata in a field 32; average number of glands 4 in 5 fields; diameter of glands 43μ; length of cells 60.3μ; width of cells 21.5μ.

I. quamoclit: Average number of stomata in a field 34; average number of glands 5 in 4 fields; diameter of glands 34μ; length of cells 55.9μ; width of cells 25.8μ.

I. sloteri: Average number of stomata in a field 18; average number of glands 1 in 2 fields; diameter of glands 39μ; length of cells 81.7μ; width of cells 34.4μ.

In the *hybrid* the cells and the stomata are larger, but the stomata and glands are less numerous than in *either parent.*

Petiole.

The shape of the *petiole* on transverse section at the *median* point, at equal distances from the lamina and the stem is illustrated in Plate 28, figs. 166, 167, and 168.

The two upper ridges are close together in *I. coccinea;* far apart in *I. quamoclit;* and between the extremes of the parents in the *hybrid.* The *angle* between the two ridges is 60° in *I. coccinea,* 130° in *I. quamoclit,* and 75° in the *hybrid.* The *general outline* is rounded in *I. coccinea,* angular in *I. quamoclit,* and generally rounded, but with a trace of angularity in the *hybrid.* (Table J 8.)

Table J 8.—*Angles, outlines, layers, cells, vasa, and epidermis of median point of petiole.*

I. coccinea: Angle between the two ridges 60°; outline rounded; cortex layers 5; diameter of cortex cells 56μ; of largest vasa 47μ; depth of epidermis 30μ.

I. quamoclit: Angle between the two ridges 130°; outline angular; cortex layers 3 to 4; diameter of cortex cells 65μ; largest vasa 39μ; depth of epidermis 26μ.

I. sloteri: Angle between the two ridges 75°; outline intermediate; cortex layers 4 to 5; diameter of cortex cells 69μ; of largest vasa 56μ; depth of epidermis 30μ.

In the *hybrid* the number of cortex layers, the angle between the two ridges, and the outline are between those of the *two parents;* the depth of the epidermis is identical with that of *I. coccinea;* the diameters of the cortex cells and of the largest vasa are larger than those of the *parents*.

Pieces of the *epidermis* at the *base* of the petiole under the same magnification show the characteristics given in Table J 9:

TABLE J 9.—*Cells, glands, and multicellular protuberances of epidermis at base of petiole.*

I. coccinea: Cells 60 by 22μ; glands 1; diameter of glands 34μ; length of multicellular protuberances 144μ.

I. quamoclit: Cells 112 by 30μ; glands 1; diameter of glands 34μ; length of multicellular protuberances 101μ.

I. sloteri: Cells 82 by 34μ; glands 2; diameter of glands 52μ; length of multicellular protuberances 364μ.

In the *hybrid,* the number of glands is greater, the glands are larger, and the multicellular protuberances are larger, than in *either parent.* (Plate 28, figs. 169, 170, and 171.)

FLOWER.

The *corolla* is composed of three layers: the upper epidermis, a spongy mesophyll, and a lower epidermis. Portions of these layers were examined between two points of the corolla limb.

The *upper epidermis* is composed of *papillose cells,* those of the *hybrid* being larger than in *either parent.* (Plate 29, figs. 172, 173, and 174.)

The sizes of cells of upper epidermis of the corolla are for *I. coccinea* 25 by 17μ, *I. quamoclit* 22 by 17μ, *I. sloteri* 29 by 22μ.

The *mesophyll* of *I. coccinea* is not spongy, and is composed of cells that are joined together without intercellular spaces. That of *I. quamoclit* is very spongy with large intercellular spaces and cells that are narrow and many branched. That of the *hybrid* combines the characters of *both parents.* There is a very slight suggestion of the cells narrowing into protuberances, but excepting their greater size the cells rather resemble those of *I. coccinea.* Large intercellular spaces are also present; these are not as large as those of *I. quamoclit.*

The *lower epidermal* cells of *I. coccinea* (Plate 29, figs. 175, 176, and 177) are slightly wavy and thin-walled, and the thickenings at the angles are very slight. Those of *I. quamoclit* are larger, with very wavy and slightly thicker walls, and with more thickening at the angles than in *I. coccinea.* Those of the *hybrid* are larger than in *either parent,* and the diameter of the walls is between those of the parents as to waviness and thickening at the angles.

The upper surface of the *limb of the corolla* in *I. coccinea* is of a vermillion color with a small yellow area around the opening of the *corolla tube.* The yellow color is due entirely to the presence of deep yellow chromoplasts in the upper epidermal cells. The vermillion is due to a combination of yellow chromoplasts, which are present in all of the cells, with a deep vermillion cell sap which is present in some of the cells. In *I. quamoclit* the upper surface of the limb is crimson, due to the presence of crimson cell sap and deeper crimson-red globules in the upper epidermal cells. Very small *plastids* are seen in the cells, but which must be either leucoplasts or very pale yellow chromoplasts, as the color, if present, is obscured by the deeply colored cell-sap. In the *hybrid* the upper surface of the limb is scarlet, a brilliant red with a trace of yellow due to a combination of yellow chromoplasts, which are present in all of the upper epidermal cells, with a pinkish red cell sap which is present in some of them.

The *outer epidermal* cells of the *corolla tube* are thin-walled and only slightly wavy in *I. coccinea;* thick and wavy in *I. quamoclit;* and intermediate in thickness and waviness but larger in the *hybrid.* These cells contain chromoplasts which are small and indistinct in *I. coccinea;* but large and distinct in *I. quamoclit* and the *hybrid.*

The sizes of the cells of the outer epidermis of the corolla tube are for *I. coccinea* 68 by 11μ; *I. quamoclit* 58 by 11μ; *I. sloteri* 98 by 14μ.

The color of the *exterior* of the *corolla tube* in *I. coccinea* is yellow-orange to orange-red, due to the presence of yellow chromoplasts in all of the outer epidermal cells and to a pinkish-red cell sap in some cells. In *I. quamoclit* the color is reddish-pink, due to the presence of a pinkish-red cell sap in some cells and deeper red globules in most of the cells. Colorless plastids are seen. In the *hybrid* the color is vermillion-red, due to the presence of yellow chromoplasts in all of the cells and a pinkish-red cell sap in some, and to a few red globules in some cells.

The color of the *interior* of the *corolla tube* in *I. coccinea* is deep yellow, due to the presence of deep orange-yellow chromoplasts in the inner epidermal cells. In *I. quamoclit* the color is pale pink. The inner epidermal cells contain yellow chromoplasts. The pinkish appearance is due to the reddish-pink color of the exterior of the *corolla tube* showing through. In the *hybrid* the color is orange-yellow, due to the presence of orange-yellow chromoplasts in the inner epidermal cells.

STAMENS.

Numerous multicellular glands, or glandular shaggy hairs as they are termed by Solereder, are found at the base of the filaments. They consist of a multicellular pedestal and a large, ellipsoidal, glandular cell. (Plate 27, figs. 163, 164, and 165.) They are much longer in *I. quamoclit* than in *I. coccinea,* and in the *hybrid* are practically mid-intermediate between the *two parents.*

The lengths of the multicellular glands of the stamens are for *I. coccinea* 111.8μ, *I. quamoclit* 408.5μ, *I. sloteri* 275.2μ.

COMPARATIVE SUMMARY OF THE CHARACTERS OF THE HYBRID I. SLOTERI AND ITS PARENT-STOCKS.

The hybrid was found to be:

(1) *The same or practically the same as the seed parent in the following characters:* In the length of primary root before branching, number of cork layers and the average diameter of the pitted vessels, and the diameter of the largest pitted vessels on the transverse section of the root; the number of cortex layers and the number of secretory cells in the transverse section of the stem; the number of stomata on the upper epidermis of the leaf at the apex; the width of the lower epidermal cells of the leaf at the base; the depth of the epidermis on the transverse section of the petiole.

(2) *The same or practically the same as the pollen parent:* In the number of capsules maturing on one flower-stalk; the number of sclerenchyma patches in the

transverse section of the root; the length of the upper epidermal cells of the leaf at the apex; the size of the chromoplasts in the outer cells of the corolla tube.

(3) *The same or practically the same as both parents:* In the depth of the epidermal cells of the transverse section of the stem; the width of the upper epidermal cells of the leaf at the base.

(4) *Intermediate:* In the shape of the cotyledons; length of the midrib ♀, length of petiole ♀, and the angle between the lobes of the cotyledons; the distance from the ground before the stem branches ♂; shape of the lamina of the mature leaf; length of the lamina ♀; length of the petiole ♂; number of flowers on one flower-stalk; shape of the corolla limb; color of the corolla tube; color of corolla limb; shape of sepals; color of anthers; color of filaments; shape of capsule; length of seeds ♂; relationship of peduncle to pedicel; waviness of upper epidermal cell walls of cotyledons; number of glands on upper epidermis ♂; waviness of lower epidermal cell walls; number of glands on lower epidermis ♀; number of cortex layers, grouping of pitted vessels, position of largest vessels and width and distinctness of medullary rays on the transverse section of the root; the diameter of the sclerosed cells ♀; the number of crystal cells in intraxylary phloem in the transverse section of the stem; the number of stomata ♀, the number of glands ♀, at the base; the number of glands on the upper epidermis of the leaf at the base; the number of hairs, the stiffness of hairs, the length of the papillæ along the veins ♀; the length of papillæ along the margin ♀, and the position of the stomata and glands on the upper epidermis of the leaf at the base; the number of glands on the upper epidermis of the leaf at the apex; the number of glands on the lower epidermis of the leaf at the base; the diameter of the glands on the lower epidermis of the leaf at the apex; the angle between the ridges ♀; the outline and the number of cortex layers in the transverse section of the petiole; the length of the epidermal cells ♀ at the base of the petiole; the shape of the mesophyll cells of the corolla limb; the waviness of the cell walls and the thickening at the angles of the lower epidermal cells of the corolla limb; the thickness and the waviness of the outer cells of the corolla tube; the length of multicellular glands at the base of the filaments.

(5) *Higher than in either parent:* In the diameter of roots ♀; extensiveness of root system ♀; diameter of stem ♀; growth of stem ♀; length of branches ♀; number of leaves ♂; width of lamina ♀; firmness of texture of lamina ♀ = ♂; duration of green leaves ♀ = ♂; resistance to insects ♀ = ♂; length of flower-stalk ♀; length of corolla tube ♂; diameter of corolla limb ♀ = ♂; diameter of corolla tube opening ♂; length of filaments ♀ = ♂; width of seeds ♀; length of upper epidermal cells ♀ and width of upper epidermal cells ♂ of the cotyledons; size of glands ♀, and size of stomata ♀ of the upper epidermis of the cotyledons; length of lower epidermal cells ♀, width of lower epidermal cells ♀ = ♂, size of lower epidermal glands ♀, and size of lower epidermal stomata ♀ of the cotyledons; length of cork cells ♀; width of cork cells ♀ = ♂; length of cork cambial cells ♂; width of cork cambial cells ♂; length of cortex cells ♂; width of cortex cells ♀ on the transverse section of the root; width of epidermal cells ♀; number of cork layers ♀ = ♂; length of cork cambial cells ♀; width of cork cambial cells ♀ = ♂; length of endodermal cells ♀; width of endodermal cells ♀; number of chambered crystal cells ♀, greater development of wood ♀, diameter of largest vessels ♀ in the transverse section of the stem; diameter of glands ♀, length of hairs ♂, and length of cells ♀ of the upper epidermis of the leaf at the base; width of cells ♀ = ♂; diameter of glands ♀, length of hairs ♂, length of papillæ along veins ♀ = ♂ of the upper epidermis of the leaf at the apex; diameter of glands ♀ and length of cells ♀ of the lower epidermis of the leaf at the base; the length of cells ♀, the width of cells ♀, of the lower epidermis of the leaf at the apex; the diameter of the cortex cells ♂, and the diameter of the largest vessels ♀ on the transverse section of the petiole; the width of the cells ♂, the number of glands ♀ = ♂, the diameter of glands ♀ = ♂, and the length of the multicellular protuberances ♀ of the epidermis at the base of the petiole; the length of the upper epidermal cells ♀, and the width of the upper epidermal cells ♀ = ♂, and the size of the lower epidermal cells of the corolla limb; the length of the outer cells ♀, and the width of the outer cells ♀ = ♂ of the corolla tube.

(6) *Lower than in either parent:* Number of seeds in a capsule ♂; proportion of seeds that germinate ♀ = ♂; number of stomata on the upper epidermis of the cotyledons ♀; number of stomata on the lower epidermis of the cotyledons ♂; number of protoxylem patches ♀ in the transverse section of the stem; number of stomata ♀ on the lower epidermis of the leaf at the base; number of stomata ♀, and number of glands ♀, on the lower epidermis of the leaf at the apex.

TABLE J 10.—*Summary of characters of hybrid-stock as regards sameness, intermediateness, excess, and deficit of development in relation to parent-stocks.*

	Macroscopic.	Microscopic.	Total.
Same as seed parent	1	8	9
Same as pollen parent	1	3	4
Same as both parents	0	2	2
Intermediate	18	31	49
Highest	16	45	61
Lowest	2	6	8

2. MACROSCOPIC AND MICROSCOPIC CHARACTERS OF LÆLIA PURPURATA, CATTLEYA MOSSIÆ, AND LÆLIO-CATTLEYA CANHAMIANA.

(Plate 30, figs. 178 to 183. Tables J, 11 to 20; and I, 2 and Summaries. Chart F 2.)

GENERAL DESCRIPTIONS.

Data for these descriptions were obtained from Veitch (Manual of Orchidaceous Plants, I, 22, 180), Engler and Prantl (Die Natürlichen Pflanzen-familien, II, Th. 6, 146, 147), Lindley (Botanical Magazine, T. 3669), and Sander (Orchid Guide, 98, 24, 100).

Lælia purpurata Lindl. and Paxt. (*Seed Parent*).—Stems oval, compressed, smooth. Pseudobulbs inclosed by a scaley sheath and ridged when old. Leaves long, leathery, dark green above, paler beneath, persistent. Peduncles arise from green, leathery, flattened sheaths about 6 and a half inches long and are 3 to 7 flowered. Flowers large; sepals oblong-lanceolate, acute, white or white tinted and veined with very pale amethyst-purple;

petals ovate-oblong with a wavy margin, wider than the sepals and colored like them; labellum obscurely 3-lobed, the basal part convolute around the column into a tube, exterior white, the interior pale yellow with purple lines, the anterior part spreading with crisped margin and of a rich crimson-purple; column clavate, bent, greenish; pollinea 8 in 2 series of 4, very small.

Cattleya mossiæ Hook. (*C. mossiæ* Parker) (*Pollen Parent*).—Stems oval, slightly compressed. Pseudobulbs surrounded by a membranaceous sheath and ridged when old. Leaves tough, leathery, dark green above, paler beneath, persistent. Peduncles arise from green flattened sheaths, about 2 and a half inches long, 3-flowered. Flowers large; sepals lanceolate, rose-lilac; petals ovate, wider than the sepals, with a wavy margin, of the same color as the sepals; labellum obscurely 3-lobed, the basal part convolute around the column into a tube, externally of the same color as the petals, internally towards the center, pale yellow obliquely striated with purple, the margin like the petals, the upper or anterior part divided into two areas, the one toward the posterior being a yellow band that extends obliquely towards the sides; that nearer the apex being a rich velvety purple area mottled with lilac and at the margin becoming pale lilac, the margin is crisped and cleft rather deeply at the middle of the anterior lobe; column club-shaped, grooved beneath, and expanded into two wing-like margins; pollinea are 4, in 2 pairs, large, compressed, each with a ribbon-like tail.

Lælio-Cattleya canhamiana (*Hybrid*).—Stems oval, compressed, smooth. Pseudobulbs inclosed by scaley bracts, and ridged when old. Leaves tough, green, leathery, persistent. Peduncles arise from green, leathery, flattened sheaths 5 inches in length, bearing in this specimen 3 flowers. Flowers large; sepals are oblong lanceolate and light rose in color; petals wider than the sepals, of the same color, and have a wavy margin; labellum obscurely 3-lobed; basal part convolute around the column; on the interior, towards the center, orange with oblique brown stripes, the margin white, on the exterior of the same color as the petals, the anterior part broad with a crisped margin and deep crimson-purple, paler at the margin, and cleft slightly in the middle of the anterior lobe; column white with light green on the sides; pollinea unequal in size, 4 being large, resembling those of the Cattleya parent, and 4 much smaller, like those of the Lælia parent.

Comparisons of the Macroscopic Characters.

Roots.

The roots are cylindrical and fleshy, similar in all three plants, and arise from a point on the rhizome just below the pseudobulb. The rhizomes are green, about half an inch in diameter, and lie above the surface of the ground, forming a connection between the pseudobulbs.

Pseudobulbs.

The *pseudobulbs* are the thickened first, second, and third internodes. The first and second are only slightly thickened, forming a sort of slender stem; the third is very much thickened and elongated. They are larger in *Lælia purpurata* than in *C. mossiæ*. Those of the *hybrid* are smaller than those of *either parent*, but this may have been due to the plant itself being in a rather poor condition. (Table J 11.)

Table J 11.—*Lengths and widths of pseudobulbs.*

L. purpurata: Length 22.4 cm.; greatest width 3.3 cm.
C. mossiæ: Length 16 cm.; greatest width 2.5 cm.
L.-C. canhamiana: Length 15.6 cm.; greatest width 2.4 cm.

The old pseudobulbs of *L. purpurata* are almost smooth, the outline of the transverse section being only moderately wavy; those of *C. mossiæ* are deeply ridged; and those of the *hybrid* are in extent of ridging between those of the parents, but nearer *L. purpurata.* The pseudobulb is sheathed by 3 small green leaves which gradually dry out and become thin and membranaceous. At the top of the pseudobulb there is given off one *mature leaf,* which in *both parents* and *hybrid* is long, green, and leathery. (Table J 12.)

Leaf.

The leaves are very nearly alike in the three plants, except in size. Those of *L. purpurata* are much longer and a little broader than those of *C. mossiæ,* and in the *hybrid* they are almost exactly mid-intermediate in length, and between the parents in width, but much nearer the width of *L. purpurata.*

Flower.

The flowers arise from the axils of very small bracts on a cylindrical flower-stalk. This stalk with its buds is inclosed in a sheath which in *L. purpurata* is large, compressed, green, and leathery, and in *C. mossiæ* and the *hybrid* is small, yellowish green, and more dried-out looking. The *flower-stalk* is much longer in *L. purpurata* than in *C. mossiæ*; and in the *hybrid,* though between the two in length, it is nearer *C. mossiæ.* (Table J 12.) Of the plants examined, *L. purpurata* bore 5 flowers and *C. mossiæ* and the *hybrid* each 3. The *pedicel* is shorter in *L. purpurata* than in *C. mossiæ,* and longer in the *hybrid* than in *either parent.* (Table J 12.)

Table J 12.

Lengths and widths of leaves of pseudobulbs:
L. purpurata: Average length 30 cm.; average width 5.8 cm.
C. mossiæ: Average length 22.3 cm.; average width 5.3 cm.
L.-C. canhamiana: Average length 26.6 cm.; average width 5.7 cm.
Lengths of flower-stalks:
L. purpurata 26 cm.
C. mossiæ 15.2 cm.
L.-C. canhamiana 18.7 cm.
Lengths of pedicels:
L. pupurata 5.1 cm.
C. mossiæ 6.2 cm.
L.-C. canhamiana 8 cm.

The *sepals* of *L. purpurata* are all similar; they are long and narrow and recurved toward the base and curved upward toward the apex; and without trace of a nectary on the apex. Those of *C. mossiæ* have a longer dorsal sepal and sickle-shaped lateral ones; they curve over at the apex; and each has a green nectary on the lower surface of the apex. In the *hybrid* there are the combined characters of *both parents.* The dorsal sepal is a little longer than the lateral ones, but the difference is not so great as in *C. mossiæ.* The lateral sepals are

very slightly sickle-shaped; they are curved toward the base and curve upwards toward the apex, but this is not so pronounced as in *L. purpurata;* and there are green nectaries at the apices, though these are not so large as in *C. mossiæ.* (Table J 13.)

The *sepals* and *petals* of *L. purpurata* are white with pale lilac veins; those of *C. mossiæ*, pink-lilac; and those of the *hybrid,* a paler pink-lilac.

The *petals* are shorter and narrower in *L. purpurata* than in *C. mossiæ,* and in the *hybrid* are very nearly mid-intermediate in length and width but slightly nearer *C. mossiæ.* (Table J 13.)

The *labellum* is very nearly the same length in the *parents* and *hybrid,* but is wider in the *hybrid* than in *either parent.* (Table J 13.)

TABLE J 13.

Lengths and widths of sepals:
- *L. purpurata:* Length of dorsal sepals 10.2 cm.; of lateral sepals 10.2 cm.; width of sepals 2.1 cm.
- *C. mossiæ:* Length of dorsal sepals 10.5 cm.; of lateral sepals 9 cm.; width of sepals 2.3 cm.
- *L.-C. canhamiana:* Length of dorsal sepals 10.5 cm.; of lateral sepals 9.8 cm.; width of sepals 2.4 cm.

Lengths and widths of the petals:
- *L. purpurata:* Length 9.5 cm.; width 4.4 cm.
- *C. mossiæ:* Length 10.3 cm.; width 5.7 cm.
- *L.-C. canhamiana:* Length 10 cm.; width 5.2 cm.

Lengths and widths of labellum:
- *L. purpurata:* Length 8.1 cm.; width 6 cm.
- *C. mossiæ:* Length 8.2 cm.; width 6 cm.
- *L.-C. canhamiana:* Length 8 cm.; width 6.7 cm.

The anterior part of the *labellum* in *L. purpurata* has a wavy margin; that of *C. mossiæ* is very wavy, the indentations being comparatively deep; and that of the *hybrid* between the *parents* but slightly nearer *L. purpurata.* The *tip* of the labellum is pointed in *L. purpurata,* and in a few specimens it is slightly indented, about 2 mm. deep; in *C. mossiæ* there is quite a deep cleft, on an average 9 mm. deep; in the *hybrid* the cleft is not quite so deep, about 3 to 4 mm. The upper surface of the basal half of the *labellum* in *L. purpurata* is white with a yellowish tinge, and with reddish-purple veins. In *C. mossiæ* the basal part (not quite half of the labellum) at the margin is lilac, like the petal and sepals, and a pale yellow between the reddish brownish-purple veins. The rest of the basal half and part of the apical half is yellow, with brownish-purple veins. In the *hybrid* the basal part (not quite half of the labellum) at the margin is white, and yellowish-white between the red-violet veins. The part corresponding to the yellow area of *C. mossiæ* does not include quite so much of the apical half as in *C. mossiæ,* it is of a paler shade of yellow, and it is not so distinct an area as in *C. mossiæ,* the white basal area blending gradually into the pale yellow area. The *apical half of the labellum* in *L. purpurata* is a rich, velvety crimson-purple fading to pinkish-white at the extreme tip; that of *C. mossiæ* is blotched magenta with a distinct pale lilac margin; that of the *hybrid* has near the tip a blotched magenta area very similar to that of *C. mossiæ,* and posterior to this a darker colored area more like the crimson-purple of *L. purpurata,* becoming paler towards the margin and more of a lavender.

The *column* in *L. purpurata* is white with a few purple dots and purple margins on the anterior face; that of *C. mossiæ* is entirely white; that of the *hybrid* is white with a few purple specks on the anterior face and suffused with pale pink lilac on the posterior face. (Table J 14.)

TABLE J 14.—*Lengths and widths of the column.*

- *L. purpurata:* Length 3 cm.; width 1 cm.
- *C. mossiæ:* Length 4 cm.; width 0.9 cm.
- *L.-C. canhamiana:* Length 3 cm.; width 0.95 cm.

The *pollinia* in *L. purpurata* are 8 small masses, 2 by 1.3 mm.; in *C. mossiæ,* 4 much larger masses with tails, 3 by 2 mm.; and in the *hybrid,* 4 large masses with tails 3 by 2 mm. and 2 small masses 1 by 0.5 mm.

COMPARISONS OF THE MICROSCOPIC CHARACTERS.

ROOTS.

The roots of *L.-C. canhamiana* were in poor condition, on which account studies were not made of this part of the plant.

PSEUDOBULBS.

Pseudobulbs of the same age were sectioned at the middle of the thickened part, the third internode (Plate 30, figs. 178, 179, and 180). The *epidermis* in *L. purpurata* and the *hybrid* is composed of rather thick-walled cells that are deeper than wide; those of *C. mossiæ* are practically as deep as wide. The depth of the epidermis cells of *L. purpurata* is much greater than that of *C. mossiæ,* while in the *hybrid* it is only slightly less than in *L. purpurata.* The width is much less in the *hybrid* than in *either parent.* (Table J 15.)

TABLE J 15.—*Depth and width of cells of epidermis of pseudobulb.*

- *L. purpurata:* Depth 42.5μ; width 33.5μ.
- *C. mossiæ:* Depth 30.9μ; width 31.3μ.
- *L.-C. canhamiana:* Depth 41μ; width 20.2μ.

The outer face of the epidermal cells is provided with a very thick *cuticle* which is of the same depth (28.8μ) in *both parents,* but much deeper in the *hybrid* (39.6μ) than in the parents. Beneath the epidermis in *L. purpurata* are 2 layers of thick-walled, radially elongated cells. In *C. mossiæ,* the first layer consists of thick-walled, non-elongated cells, and the second layer of cells not quite as thick-walled. In the *hybrid* there are two layers of cells not quite as thick-walled, nor as elongated, as in *L. purpurata.* In the *hybrid* the length of the cells of the first layer is intermediate between the *parents* and slightly nearer that of *C. mossiæ;* they are narrower than in *either parent,* and in thickness of cell wall intermediate but nearer *L. purpurata.* (Table J 16.)

TABLE J 16.—*Depth, width, and thickness of walls of first layer of cells beneath the epidermis.*

- *L. purpurata:* Depth 108.4μ; width 38.9μ; thickness of walls 10.8 to 14.4μ.
- *C. mossiæ:* Depth 40.7μ; width 36μ; thickness of walls 3.6μ.
- *L.-C. canhamiana:* Depth 70.6μ; width 28μ; thickness of walls 7.2 to 10.8μ.

Within the thickened *hypodermal tissue* are the bundles which are embedded in a tissue of large, thin-walled cells. Some of the latter contain needle crystals; others, starch grains; and others, mucilaginous matter.

LEAF.

Sections of the *upper epidermis of the leaf* were made at the apex, middle, and base of the leaf. The epidermal cells are rectangular, pentagonal, or hexagonal, always

longer than broad, and with thick walls. The cells of *L. purpurata* are larger than those of *C. mossiæ;* those of the *hybrid* at the apex are between those of the *parents,* but those at the middle are in the *hybrid* much shorter, and at the base they are narrower than in the *parents.* The average size of the cells for the whole leaf is in the *hybrid* between those of the *parents,* but very much nearer *C. mossiæ.* (Table J 17.)

Sections of the *lower epidermis* were taken from the same regions as those of the upper epidermis. The cells are similar to those of the upper epidermis in shape and thickness of walls. Those of *L. purpurata* are larger than those of *C. mossiæ,* except at the base of the leaf where they are a little shorter. Those of the *hybrid* at the apex are between those of the *parents* in both length and width and at the base in width; but at the middle are smaller than in *either parent* in both dimensions, and also less in length at the base. The average size of the cells for the entire leaf in the *hybrid* is less in length than in *either parent* and between the two in width, though much nearer *C. mossiæ.* (Table J 17.)

TABLE J 17.

	L. purpurata.		C. mossiæ.		L.-C. canhamiana.	
	Length.	Width.	Length.	Width.	Length.	Width.
	μ	μ	μ	μ	μ	μ
Size of cells of upper epidermis:						
At apex......	65.5	43.9	54	33.5	57.9	38.2
At middle....	53.3	32.8	51.8	31.7	47.9	31
At base......	47.2	36	41.2	32.4	43.2	29.2
Average for entire leaf....	55.4	37.4	49.3	32.4	49.7	33.1
Size of cells of lower epidermis:						
At apex......	48.6	33.1	40.3	27.7	42.5	29.2
At middle....	39.2	27	38.9	26.6	34.9	25.2
At base......	37.4	29.9	37.8	21.2	35.6	24.1
Average for entire leaf....	41.8	29.9	38.9	25.2	37.8	26.3

Stomata are less numerous in *L. purpurata* than in *C. mossiæ,* and more numerous in the *hybrid* than in *either parent.* (Table J 18.)

TABLE J 18.—*Number of stomata in a field on lower epidermis.*

L. purpurata: At apex 8; at middle 8.9; at base 5.6; average for entire leaf 7.5.

C. mossiæ: At apex 10.7; at middle 11.5; at base 7; average for entire leaf 9.7.

L.-C. canhamiana: At apex 11.2; at middle 12.6; at base 9.8; average for entire leaf 11.2.

Transverse sections of *leaves* of the same age at a distance of 1 inch from the apex were made at the midrib and at the first main vein from the midrib (Plate 30, figs. 181, 182, and 183). At the midrib, the *upper epidermis* is composed of rectangular, rather thick-walled cells having a very heavy cuticle on the outer face. The cells of *L. purpurata* become smaller toward the midrib angle; those of *C. mossiæ* become greatly elongated; and those of the *hybrid* become elongated though not to such an extent as in *C. mossiæ.*

The *cuticle on the upper epidermis* in the *hybrid* is much deeper than in *either parent.* (Table J 19.)

TABLE J 19.

	L. purpurata.	C. mossiæ.	L.-C. canhamiana.
	μ	μ	μ
Thickness of cells of upper epidermis at first main vein from midrib and at midrib:			
At first vein from midrib..	36	32.4	32.4
At midrib..............	28.8	72	43.2
Depth of cuticle............	28.8	14.4	39.6
Lengths of subepidermal cells.	79.21	144 to 216	144 to 216
Depth of lower epidermis and cuticle:			
Depth of lower epidermis..	39.6	43.2	32.4
Depth of cuticle.........	18	14.4	18
Depth and width of midrib bundle and depths of sclerenchyma sheath, phlœm, and xylem:			
Depth by width of entire bundle.........	342 by 342	234 by 226.8	216 by 216
Depth by sclerenchyma sheath...............	86.4	43.2	43.2
Depth of phlœm..........	54	64.8	43.2
Depth of xylem..........	144	126	72
Depths and width of cells of upper epidermis and depth of cuticle:			
Depth of cells...........	36	32.4	32.4
Width of cells...........	46.8	43.2	39.6
Depth of cuticle.........	25.2	18	21.6
Depths and widths of cells of first layer beneath upper epidermis:			
Depth..................	47.9	38.2	33.1
Width..................	81.7	60.5	64.4
Depth and width of cells of lower epidermis and depth of cuticle:			
Depth of cells...........	38.5	30.2	34.9
Width of cells...........	53.6	34.6	36.7
Depth of cuticle.........	25.2	10.8	18
Depth and width of cells of first layer beneath lower epidermis:			
Depth..................	43.9	28.1	36.4
Width..................	62.6	44.3	49.3
Depth and width of cells of epidermis:			
Depth..................	25.2	20.2	25.9
Width..................	32	22.7	21.2
Average depth and width of cells of hypodermis:			
Depth..................	32.4	18.4	20.9
Width..................	42.5	29.9	29.9
Width of cortical cylinder...	756	687.6	601.2
Average length and width of largest bundles:			
Length.................	360	306	234
Width..................	270	198	162
Length of bundles and depth and proportion of phlœm:			
Length of bundle.........	360	306	234
Depth of phlœm *........	126	54	61.2
Length and width of cells of upper epidermis at middle of sepal:			
Length.................	91.4	88.5	111.9
Width..................	61.9	72	70.2
Length and width of cells of lower epidermis at middle of sepal:			
Length.................	99.3	75.2	81.7
Width..................	65.4	58.3	63

* Proportion of phloem, *L. purpurata,* one-third; *C. mossiæ,* one-sixth; *L.-C. canhamiana,* one-fourth.

TABLE J 19.—*Continued.*

	L. purpurata.	C. mossiæ.	L.-C. canhamiana.
	μ	μ	μ
Length and width of cells of upper epidermis at middle of petal:			
Length	83.5	107.3	104.4
Width	59.8	80.6	79.2
Length and width of cells of lower epidermis at middle of petal:			
Length	94.7	101.4	115.5
Width	69.1	65.5	83.2
Length of papillæ of upper epidermal cells of middle lobe of labellum	55.4	163.8	85.7
Length and width of cells of upper epidermis of middle lobe of labellum:			
Length	64.8	73.8	96.8
Width	46.4	61.6	68.8
Length of papillæ of cells of lower epidermis of middle lobe of labellum	45.4	62.6	51.1
Length and width of lower epidermal cells of middle lobe of labellum:			
Length	77.8	90.4	92.9
Width	57.6	68.8	67.7
Length and width of cells of upper epidermis at proximal part of labellum:			
Length	52.6	74.9	66.9
Width	41.8	44.6	50.4

The two layers of *aqueous tissue* beneath the upper epidermis have thin cells lengthened at the midrib angle, the first layer being particularly noticeable. The cells of the first layer are much longer in *C. mossiæ* than in *L. purpurata,* and those of the *hybrid* are about as long as those of *C. mossiæ.* (Table J 19.)

The *lower epidermis* consists of rather thick-walled cells which at the midrib angle are deeper than wide. The lower epidermis of *C. mossiæ* is deeper than that of *L. purpurata,* but that of the *hybrid* is not as deep as those of the *parents.* The *cuticle on the lower epidermis* is of the same depth in the *hybrid* as in *L. purpurata,* both being of greater depth than in *C. mossiæ.* (Table J 19.)

Beneath the lower epidermis at the midrib in *L. purpurata* is one layer of cells which is not different from the layers beneath it, excepting for the slightly smaller size of the cells. In *C. mossiæ* there are two distinct layers of oval cells longer than deep and smaller than the other cells, and arranged more closely together. In the *hybrid* there is one distinct layer of closely packed oval cells and a layer of cells beneath, which are a little smaller than those of the underlying layers. (Table J 19.)

The *midrib bundle* is much larger in *L. purpurata* than in *C. mossiæ* and is smaller in the *hybrid* than in *either parent.* Lowermost in this bundle is a somewhat crescentic area of heavily thickened cells, the *sclerenchyma.* This is just twice as thick in *L. purpurata* as in *C. mossiæ* and the *hybrid.* Just above this is a small patch of *phloem* which is smaller in *L. purpurata* than in *C. mossiæ,* and smaller in the *hybrid* than in *either parent.* Above this is an area of xylem consisting of thick-walled cells, which area is larger in *L. purpurata* than in *C. mossiæ* and smaller in the *hybrid* than in *either parent.* (Table J 19.)

Examined at the *first main vein from the midrib,* the *upper epidermis* appears as a layer of thick-walled, rectangular cells, slightly rounded at the angles, and with a thick cuticle on the outer face. The cells of *L. purpurata* are larger than those of *C. mossiæ,* while those of the *hybrid,* though of the same depth as those of *C. mossiæ,* are not so wide as in the *parents.* The cuticle of the *hybrid* is in depth exactly mid-intermediate between the depths of the *parents.* (Table J 19.)

Beneath the upper epidermis is a layer of oval rectangular cells and beneath this a layer of rather irregularly shaped cells, both layers containing very few chloroplasts. These compose the *aqueous tissue.* The *cells of the first layer beneath the epidermis* are larger in *L. purpurata* than in *C. mossiæ,* and in the *hybrid,* though between the parents in width, the depth is less than that of *either parent.* (Table J 19.)

The cells of the *lower epidermis* are much wider than deep in *L. purpurata,* and slightly wider than deep in *C. mossiæ* and the *hybrid,* but the difference between width and depth is so small that they appear almost square. The cells of the *hybrid* are in size between those of the *parents* though very near *C. mossiæ.* They are thick-walled like those of the upper epidermis, and provided with a thick cuticle on the outer face, which latter in the *hybrid* is exactly mid-intermediate in depth between those of the *parents.* (Table J 19.)

Just beneath the lower epidermis is a layer of oval cells which are more closely packed than the underlying cells. These oval cells are larger in *L. purpurata* than in *C. mossiæ,* and in the *hybrid,* though between the parental sizes, they are slightly nearer *L. purpurata* in depth but much nearer *C. mossiæ* in width. (Table J 19.)

Beneath the upper epidermis and the aqueous tissue are layers of *elongated palisade cells* which are thin-walled and contain green chloroplasts, and which store mucilage and starch. Beneath the palisade cells is the *spongy mesophyll,* composed of large, rounded, thin-walled cells. They contain green chloroplasts and store mucilage and starch. Embedded in the palisade tissue are strands of *sclerenchymatous tissue* arranged in a row beneath the upper epidermis (1.6 mm. objective). These strands are present in the same number in *L. purpurata* and the *hybrid,* but smaller in the *hybrid* than in *L. purpurata.* They are entirely absent in *C. mossiæ.* In *L. purpurata* 3 to 4 strands, diameter 66.2μ; in *C. mossiæ* no strands; in *L.-C. canhamiana* 3 to 4 strands, 54.7μ in diameter.

There is another row of *sclerenchymatous strands* embedded in the *spongy mesophyll* along the *lower epidermis.* These are more numerous in *L. purpurata* than in *C. mossiæ.* The number in the *hybrid* is between those of the parents, but nearer that of *L. purpurata,* and the strands are smaller than in *either parent.* In *L. purpurata* 6.9 strands in a field, 66.9μ in diameter; in *C. mossiæ* 4.9 strands in a field, 55.1μ in diameter; in *L.-C. canhamiana* 6.4 strands in a field, 47.9μ in diameter.

The bundle is essentially the same as that of the midrib, except that the sclerenchymatous sheath on the lower side is not so well developed.

Flower-stalk.

Transverse sections of the *flower-stalk* of the *parents* and *hybrid* were made at a point near the apex. Externally is a layer of rather thick-walled cells constituting the epidermis, with a thick cuticle on the outer face. These cells are oval, and wider than deep in *L. purpurata*, but somewhat spherical in *C. mossiæ* and the *hybrid*. They are much larger in *L. purpurata* than in *C. mossiæ*, and are a little deeper and narrower in the *hybrid* than in *either parent*. (Table J 19.)

Beneath the epidermis is a layer of thick-walled, oval cells, the *hypodermis*. These cells in *L. purpurata* are not regular in size, but vary from rather small cells (22 by 32μ) to cells over twice their size (54 by 68μ). In *C. mossiæ* the layer is composed of small, oval cells that are quite uniform in size. In the *hybrid* the layer resembles that in *C. mossiæ*, but the cells are a little deeper. (Table J 19.)

The cells of the first layer beneath the hypodermal layer in *L. purpurata* become larger, and in the second layer they are still larger and have attained their maximum size. In *C. mossiæ* they become larger very gradually, not reaching their maximum size until in the fourth or fifth layer. In the *hybrid* they reach their maximum size in about the third or fourth layer. These cells are rather thin-walled, contain chloroplasts, and form a *cortical cylinder* which is wider in *L. purpurata* than in *C. mossiæ* and smaller in the *hybrid* than in *either parent*. (Table J 19.)

There is not a distinct layer of cells forming an endodermis, but the bundles are embedded in fundamental tissue in the form of a rather distinct central cylinder. The bundles are larger in *L. purpurata* than in *C. mossiæ*, and smaller in the *hybrid* than in *either parent*. (Table J 19.)

There is a larger proportion of *phloem* in the bundles of *L. purpurata* than in *C. mossiæ*, and in the *hybrid* the amount is proportionately exactly mid-intermediate between those of the *parents*. (Table J 19.)

Flower.

Sections of the *upper* epidermis of the *sepal* were taken at the median point. The cells are flat in *L. purpurata:* papillose in *C. mossiæ* and less papillose in the *hybrid* than in *C. mossiæ*. The *color* present in *C. mossiæ* and the *hybrid* is due to a faint *pinkish-lavender* cell sap in the mesophyll layer, which is darker in *C. mossiæ* than in the *hybrid*. No colored sap is present in *L. purpurata*. The cells are longer and narrower in *L. purpurata* than in *C. mossiæ*. They are longer in the *hybrid* than in *either parent*, and though the width is between those of the parents it is much nearer that of *C. mossiæ*. (Table J 19.)

Stomata are present on the upper epidermis. They are much more numerous in *L. purpurata* than in *C. mossiæ*, but less numerous in the *hybrid* than in *either parent*. In *L. purpurata* 1 in 2 fields; in *C. mossiæ* 1 in 7 fields; in *L.-C. canhamiana* 1 in 11 fields.

The section of the *lower* epidermis of the *sepal* at the median point shows the lower epidermal cells to be flat, not papillose. The cells are larger in *L. purpurata* than in *C. mossiæ*, and though in the *hybrid* between the parents in size, the length is nearer that of *C. mossiæ*, but the width nearer that of *L. purpurata*. (Table J 19.)

Stomata in the lower epidermis are more numerous in *L. purpurata* than in *C. mossiæ*, and more numerous in the *hybrid* than in *either parent*. In *L. purpurata* 1 in 5.5 fields; in *C. mossiæ* 1 in 7.5 fields; in *L.-C. canhamiana* 1 in 3.6 fields.

Hairs are present on the lower epidermis at the middle of the sepal. They each consist of an awl-shaped basal cell with a thin-walled, thimble-like end cell. They are numerous and long in *L. purpurata;* rare and much shorter in *C. mossiæ;* and in the *hybrid* slightly less numerous than in *L. purpurata*, and shorter than in *either parent*. In *L. purpurata* 1 in 5 fields, 97.2μ long; in *C. mossiæ* 1 in 22 fields, 75.6μ long; in *L.-C. canhamiana* 1 in 6.3 fields, 68.4μ long.

Sections of the *upper epidermis* of the *petal* were made at a median point. The color, which is identical with that of the sepals and due to the pinkish-lavender cell sap in the mesophyll, is deeper in *C. mossiæ* than in the *hybrid*. No colored sap is present in *L. purpurata*. The cells are very slightly papillose in *L. purpurata* and smaller than in *C. mossiæ;* they are distinctly papillose in *C. mossiæ;* and in the *hybrid* they are not quite as papillose, and very nearly as large as in *C. mossiæ*. (Table J 19.)

Stomata are present on the upper epidermis. They are much more numerous in *L. purpurata* than in *C. mossiæ*, in which latter they are very rare. In the *hybrid* the number is between those of the parents, but slightly nearer *L. purpurata*. In *L. purpurata* 1 in 1.5 fields; in *C. mossiæ* 1 in 25 fields; in *L.-C. canhamiana* 1 in 6 fields.

Careful examination of the *upper epidermis* of the petal at the *middle* failed to reveal any *hairs* in *C. mossiæ* and the *hybrid*. Hairs are very rare in *L. purpurata*, only 2 having been found in 80 fields. They were similar to those on the lower epidermis of the sepal, and had an average length of 90μ.

Sections of the *lower epidermis* were made at the middle of the *petal*. The cells of the *lower epidermis* are flat in *L. purpurata;* papillose in *C. mossiæ;* and only very slightly papillose in the *hybrid*. They are shorter and broader in *L. purpurata* than in *C. mossiæ*, and larger in the *hybrid* than in *either parent*. (Table J 19.)

Stomata in the *lower epidermis* are more numerous in *L. purpurata* than in *C. mossiæ*, and more numerous in the hybrid than in *either parent*. In *L. purpurata* 1 in 5 fields; in *C. mossiæ* 1 in 9 fields; in *L.-C. canhamiana* 1 in 4.3 fields.

Sections of the *upper epidermis* of the *middle lobe* of the *labellum* were taken at about the median point. This area is crimson-purple in *L. purpurata*, due to a crimson-purple cell sap which fills the papillose epidermal cells; blotched magenta (more red than in *L. purpurata*) in *C. mossiæ*, due to a red-violet cell sap; blotched magenta in the *hybrid*, due to a red-violet cell sap. The cells are papillose in all three, but the papillæ are much more elongated and narrower in *C. mossiæ* than in *L. purpurata* and the *hybrid*. The papillæ of the *hybrid* are in length nearer those of *L. purpurata* than those of *C. mossiæ*. (Table J 19.)

The basal part of the cell is smaller in *L. purpurata* than in *C. mossiæ* and larger in the *hybrid* than in *either parent*. (Table J 19.)

Sections of the *lower epidermis* of the *middle lobe* of the *labellum* were examined. The cells are large and papillose in all three, but the papillæ are smaller in *L. purpurata* than in *C. mossiæ*. The papillæ of the *hybrid* are between those of the parents in size, though slightly nearer *L. purpurata*. (Table J 19.)

The cells of the lower epidermis of the middle lobe of the labellum are smaller in *L. purpurata* than in *C. mossiæ* and in the *hybrid*. The length is greater than that of either parent and the width greater than in *L. purpurata* and almost as great as in *C. mossiæ*. (Table J 19.)

Stomata are present on the *lower epidermis* of the middle of the labellum. They are more numerous in *L. purpurata* than in *C. mossiæ;* and in the *hybrid,* while the number is between those of the parents, it is much nearer *L. purpurata* than *C. mossiæ*. In *L. purpurata* 1 in 4 fields; in *C. mossiæ* 1 in 17 fields; in *L.-C. canhamiana* 1 in 7 fields.

Sections of the *upper epidermis* of the *proximal part* of the *labellum* were taken from the center above the veined area. The cells of *L. purpurata* are smaller than those of *C. mossiæ,* flat (not papillose), and striated; those of *C. mossiæ* are larger, distinctly papillose, and striated, the striæ being rather dense at the top of the papillæ; those of the *hybrid* are not quite so long, but broader, than those of *C. mossiæ,* and they are slightly papillose and striated. (Table J 19.)

Comparative Summary of the Characters of the Hybrid Lælio-Cattleya canhamiana and its Parent-stocks.

The hybrid is found to be:

(1) *The same or practically the same as the seed parent:* In the width of the leaves; the length of the column; the shape of the epidermal cells, and the depth of the epidermal cells in the transverse section of the pseudobulb; the depth of the cuticle on the lower epidermis on the transverse section of the leaf at the midrib region; the number of sclerenchyma strands beneath the upper epidermis, and the number of strands beneath the lower epidermis on the transverse section of the leaf at the first main vein from the midrib; the depth of the epidermal cells on the transverse section of the flower-stalk.

(2) *The same or practically the same as the pollen parent:* In the size of flower sheath; color of flower sheath; number of flowers; length of dorsal sepal; width of upper epidermal cells at the middle of the leaf; length of lower epidermal cells at the apex of the leaf; length of sub-epidermal cells, and depth of sclerenchyma sheath on the transverse section of the leaf at the midrib; depth of upper epidermal cells, width of cells of the first layer beneath, and width of lower epidermal cells on the transverse section of the leaf at the first main vein; regularity of cells of the hypodermis and width of hypodermal cells on the transverse section of the flower-stalk; width of upper epidermal cells of the sepals; length and width of upper epidermal cells of the petals; absence of hairs on the upper epidermal cells of the petals; width of the lower epidermal cells of the median lobe of the labellum.

(3) *The same or practically the same as both parents:* In the character of roots, thickness of leaves, color of leaves, length of labellum.

(4) *Intermediate:* In the ridging of old pseudobulbs ♀; length of leaves; length of flower-stalk ♂; shape of lateral sepals; nectary at apex of sepals; difference in length between lateral and dorsal sepals; length of lateral sepals ♀; color of sepals; color of petals; length ♂ and width ♂ of petals; waviness of anterior margin of labellum ♀; cleft in anterior margin of labellum ♀; color of base of labellum; color of apical half of labellum; color of anterior face of column; width of column; size of pollinea; depth of first layer beneath the epidermis ♂; thickness of walls ♀ of first layer beneath the epidermis on the transverse section of the pseudobulb; length ♂ and width ♀ = ♂ of upper epidermal cells of the leaf at the apex; length ♂ of the upper epidermal cells of the leaf at the base; while ♂ of the lower epidermal cells of the leaf at the apex; width ♂ of the lower epidermal cells of the leaf at the base; amount of elongation of the upper epidermal cells at the midrib, the length of the epidermal cells at the midrib ♀, the arrangement and size of the cells beneath the lower epidermis on the transverse section of the leaf at the midrib; the depth of the cuticle on the upper epidermis, the depth of the lower epidermal cells ♀, the depth of the cuticle on the lower epidermal cells, the depth of the cells beneath the lower epidermis ♀, and the width of the cells beneath the lower epidermis ♂, and the diameter of the sclerenchyma strands ♀ beneath the upper epidermis on the transverse section of the leaf at the first main vein; the depth of the hypodermal cells ♂, and the proportion of the phloem in the bundles on the transverse section of the flower-stalk; the size of the papillæ ♂ on the upper epidermis of the sepal; the length ♂, and width ♀, of the lower epidermal cells of the sepals; the number of hairs ♀ on the lower epidermis of the sepals ♂; the length of the papillæ, and the number of stomata ♀ on the upper epidermis of the petals; the length of the papillæ on the lower epidermis of the petals; the length of the papillæ on the upper epidermis of the middle lobe of the labellum ♀; the length of papillæ ♀ and the number of stomata ♀ on the lower epidermis on the middle lobe of the labellum; the length of the papillæ on the upper epidermis of the proximal part of the labellum; length ♂ of the upper epidermal cells on the proximal part of the labellum.

(5) *Higher than in either parent:* In the length of pedicles ♂; width of the sepals ♂; width of labellum ♀ = ♂; color of posterior face of the column ♀ = ♂; depth of cuticle ♀ = ♂ on the epidermal cells on the transverse section of the pseudobulb; number of stomata at the apex ♂, at the middle ♂, and at the base ♂, on the lower epidermis of the leaf; depth of cuticle ♀, on the upper epidermis on the transverse section of the leaf at the midrib; the length ♀ of the upper epidermal cells of the sepals; the number of stomata ♀ on the lower epidermis of the sepal; the length ♂, and width ♀, of the lower epidermal cells of the petal; the number of stomata ♀ on the lower epidermis of the petal; the length ♂, and the width ♂ of the upper epidermal cells of the middle lobe of the labellum; the length ♂ of the lower epidermal cells of the middle lobe of the labellum; the

width ♂ of the upper epidermal cells of the proximal part of the labellum.

(6) *Lower than in either parent:* In the length of the pseudobulb ♂; width of the pseudobulb ♂; width of the epidermal cells ♂, and width of cells of the first layer beneath the epidermis ♂ on the transverse section of the pseudobulb; length of the upper epidermal cells at the middle of the leaf ♂; width of the upper epidermal cells at the base of the leaf ♂; length ♂, and width ♂ of the lower epidermal cells of the leaf at the middle; length of the lower epidermal cells at the base ♀; depth of the lower epidermis ♀, depth ♂, and width ♂, of the midrib bundle ♀, depth of the phloem ♀ and depth of the xylem ♂ on the transverse section of the leaf at the midrib; width of the upper epidermal cells ♂, depth of the first layer beneath the epidermis ♂, and diameter of the lower sclerenchyma strands ♂, on the transverse section of the leaf at the first main vein; width of the epidermal cells ♂, width of the cortex ♂, length ♂, and width ♂, of the bundles on the transverse section of the flower-stalk; number of stomata ♂, on the upper epidermis of the sepals; length of the hairs ♂, on the lower epidermis of the sepals. (See Table J 20.)

Table J 20.—*Summary of characters of hybrid-stock as regards sameness, intermediateness, excess, and deficit of development in relation to parent-stocks.*

	Macroscopic.	Microscopic.	Total.
Same as seed parent..........	2	6	8
Same as pollen parent.........	4	14	18
Same as both parents.........	4	0	4
Intermediate................	18	30	48
Highest....................	4	14	18
Lowest....................	2	21	23

3. Macroscopic and Microscopic Characters of Cymbidium lowianum, C. eburneum, and C. eburneo-lowianum.

(Plate 31, figs. 184 to 189. Tables J, 21 to 28; 1, 3; and Summaries. Chart F 3.)

General Description.

Data for these descriptions were obtained from Reichenbach (Gardeners' Chronicle, 1889, 363), Veitch (Manual of Orchidaceous Plants, II, 11, 19, 23) and Sander (Orchid Guide, 34, 35, 36).

Cymbidium lowianum Reichb. f. (*Seed Parent*).—Pseudobulbs compressed, 4 to 6 inches in length. Leaves 24 to 30 inches long, lanceolate-ligulate, convolute into a tube, yellowish to 3 to 4 inches from the base, keels on the under side. Racemes robust, arching, as long as the leaves, and bearing 15 to 36 flowers (the plant which bloomed here had only 9 flowers). Bracts toward base of flower-stalk sheathing, membranaceous, the larger ones 9 cm. long. Flowers large, borne on thick, fleshy pedicels 4 to 5 cm. long; sepals and petals similar, yellowish green in color with a few faint sepia-brown lines over the main veins, sepals obscurely keeled behind, petals a little narrower than the sepals; *labellum* 3-lobed, the lateral ones erect, light yellow, the median one deltoid, reflexed with slight undulate margin, velvety, dark red-crimson with a pale yellow margin, base of labellum white, crest two-keeled; *column* arched concave with a few orange-red spots at the base on the concave face.

Cymbidium eburneum Lindl. (*Pollen Parent*).—Pseudobulbs compressed, 3 inches in length. Leaves linear, 15 to 24 inches long, convolute into a tube, yellowish 3 inches from the base, and keeled on the under side. Racemes erect, shorter than the leaves, and bearing 1 to 3 flowers. Bracts about 3 sheathing; alternate, lanceolate, acuminate. Flowers large, fragrant; sepals and petals similar, ivory-white, dorsal sepal concave and spiculate, the petals slightly narrower than the sepals and somewhat sickle-shaped; labellum 3-lobed, the lateral ones incurved toward the column and ivory-white, the median one wide, reflexed, with crisped margin, ivory-white sometimes with some scattered purple dots around the yellow disk, crest fleshy, grooved, pubescent, yellow, thickened at apex and with three raised lines extending the whole length; column arched with two narrow wings, white above, concave in front with a purple stain.

Cymbidium eburneo-lowianum (*Hybrid*).—Pseudobulbs ovoid, compressed, 2 and a half to 4 inches long. Leaves broader than in *C. eburneum,* but narrower than in *C. lowianum,* convolute and yellowish 3 to 4 inches from the base. Racemes arching, longer than the leaves, bearing in this instance 5 flowers. Bracts long, narrow, and very acuminate. Flowers large, faintly fragrant; sepals and petals similar, pale yellowish-brownish-green, with faint reddish-brown lines along the veins, the dorsal sepal bent forwards, the lateral sepals and petals spreading; labellum 3-lobed near that of *C. lowianum,* lateral lobes pale yellow, median lobe pale yellow above the crest and above that a V-shaped dark brownish-red area with pale yellow wavy margin, the crest a broad yellow band at the base rising with 2 bright yellow ridges; column ivory-white, with reddish stain near the anther case.

Comparisons of the Macroscopic Characters.

Roots.

The *roots* arise from base of pseudobulb. They are thick and fleshy, and do not differ in any important respect in the *parents* and *hybrid.*

Pseudobulbs.

The *pseudobulbs* are ovoid, compressed, surrounded by sheathing leaf bases, larger in *C. lowianum* than in *C. eburneum.* In the *hybrid* though they are in size between the *parents,* they are much nearer to *C. eburneum* than to *C. lowianum.* The following were the lengths of the pseudobulbs: *C. lowianum* 9.8 cm.; *C. eburneum* 7 cm.; *C. eburneo-lowianum* 7.6 cm.

Leaf.

The *leaves* are equitant (the first arising from the base of the pseudobulb), are rather short, then gradually increasing in length upwards. *C. lowianum* bears long wide leaves that drop rather deeply; *C. eburneum,* shorter narrower leaves that stand almost erect; the *hybrid,* leaves that are intermediate between those of the *parents* in width, length, and amount of drooping, but leaning, except in length of the leaves of the preceding year, toward *C. eburneum.* (Table J 21.)

TABLE J 21.

	C. lowianum.	C. eburneum.	C. eburneo-lowianum.
	cm.	*cm.*	*cm.*
Dimensions of leaves:			
Average length preceding year......	64.3	37.9	54
Average length this year............	45.8	21.9	27.5
Average width preceding year......	2.3	1.4	1.5
Average width this year............	2.4	1	1.2
Lengths of flower-stalk and average length of sheathing bracts:			
Length............	61.5	17	48
Average length.....	9	12.9	10.3
Length of pedicels and number of flowers:			
Length of pedicels..	4.5	3.4	4.2
Number of flowers..	9	1 to 2	5
Length and width of dorsal sepal:			
Length............	5.9	6.1	5.9
Width............	1.6	2.7	1.9
Length and width of lateral sepals:			
Length............	5.3	5.3	5.4
Width............	1.0	2.4	1.8
Length and width of lateral petals:			
Length............	5.5	5.7	5.6
Width............	1.1	1.9	1.4
Length and width of labellum:			
Length............	4.3	4.6	4.7
Width............	3.2	3.8	3.4
Length and width of column:			
Length............	3.5	4.2	4
Width............	0.9	1.1	0.9

C. lowianum has fewer leaves per year-growth than *C. eburneum,* and in the *hybrid* the number is mid-intermediate between those of the *parents.* The number of leaves per year-growth are: *C. lowianum* 7 to 9, *C. eburneum* 15, *C. eburneo-lowianum* 11 to 12.

FLOWER.

Inflorescence arises from the axil of one of the lower leaves. The *flower-stalk* is about 0.25 inch in diameter in all three plants, but is much longer in *C. lowianum* than in *C. eburneum,* and is between the parents in length in the *hybrid,* but nearer *C. lowianum.* It is sheathed at the base by long, narrow, acuminate, membranous *bracts* which are shorter in *C. lowianum* than in *C. eburneum,* and intermediate in length in the *hybrid,* though nearer *C. lowianum.* (Table J 21.)

Smaller *bracts* are present, one at the base of each flower. The flower is borne on a short, fleshy pedicel which is longer in *C. lowianum* than in *C. eburneum,* and though between the parents in length in the *hybrid,* it is nearer to *C. lowianum.* The flowers are more numerous in *C. lowianum* than in *C. eburneum,* and are fairly mid-intermediate in number in the *hybrid.* (Table J 21.)

The *dorsal sepal* in all three plants is concave and spiculate, bending forward towards the labellum. It is smaller in *C. lowianum* than in *C. eburneum,* and in the *hybrid* it is slightly wider but of the same length as in *C. lowianum.* (Table J 21.)

The *lateral sepals* (spread out toward the sides) are shorter and narrower than the dorsal sepal. They are of the same length but narrower in *C. lowianum* than in *C. eburneum,* and in the *hybrid* are slightly longer than in *either parent* and a little wider than in *C. lowianum.* (Table J 21.)

The *color* of the lower (outer) surface of the *sepals* is an olive-green with very indistinct brownish lines along the veins in *C. lowianum;* pale yellowish-green in *C. eburneum;* and a pale yellowish-brownish-green with reddish-brown lines along the veins in the *hybrid.* The upper (inner) surface is olive-green with faint brownish lines along the veins in *C. lowianum;* ivory-white in *C. eburneum;* and a pale yellowish-brownish-green with reddish-brown lines along the veins in the *hybrid.* Though in the *hybrid* the main color appears to be intermediate between those of the *parents* the brown lines are intensified.

The *petals* are longer and narrower than the sepals. They are shorter and narrower in *C. lowianum* than in *C. eburneum* and mid-intermediate in length and also very nearly so in width in the *hybrid.* (Table J 20.)

The *color* of the *petals* is more yellowish and not as green as the sepals in *C. lowianum,* ivory-white like the sepals in *C. eburneum,* and in the *hybrid* more yellowish but not as green as the sepals.

The *labellum* is shorter and narrower in *C. lowianum* than in *C. eburneum.* In the *hybrid* it is longer than in *either parent,* but the width, though between the widths of the parents, is nearer *C. lowianum.* (Table J 21.)

The *color* of the *outer surface* of the *labellum* is very similar in all three plants, an ivory-white with a yellowish area near the base, and veins a faint yellow becoming a pale greenish-yellow toward the lateral lobes. Inside at the *base* the color is yellow, speckled with yellowish red, fading to very pale yellow and becoming a slightly deeper yellow toward the lateral lobes in *C. lowianum;* ivory-white, becoming pale yellow toward the lateral lobes in *C. eburneum;* and yellow at the base, speckled with reddish brown, then ivory-white and becoming yellow toward the lateral lobes in the *hybrid.* Two white ridges arise from 2 flat bands extending along the median line of the labellum, ending in a faintly yellow crest in *C. lowianum;* there are three yellow ridges, ending in a yellow crest in *C. eburneum;* and a broad flat band gradually rising into 2 yellow ridges with 2 brown specks on the crest in the *hybrid.* Above the crest is a white area in *C. lowianum,* corresponding to this is a small yellow spot in *C. eburneum,* and a paler yellow spot in the *hybrid.* Extending from between the two crests is a red line and a V-shaped mark of red-crimson in *C. lowianum;* the corresponding area is yellow and ivory-white in *C. eburneum;* and a V-shaped mark of dark brownish-red in the *hybrid.* Between the anterior lobe and each lateral lobe of the labellum is a speckled area. The color of the dots in *C. lowianum* is yellowish red; in *C. eburneum,* pale purplish; and in the *hybrid,* reddish brown.

The *column* is shorter and narrower in *C. lowianum* than in *C. eburneum.* In length it is between the parents in the hybrid, though near *C. eburneum;* but in width it is identical with *C. lowianum.* (Table J 21.)

The *color of the column* on the *inner surface* is, in *C. lowianum,* yellowish at the base with orange-brown

specks, becoming whitish and greenish white toward the top; in *C. eburneum,* yellow at the base, then ivory-white spotted with pale purple; in the *hybrid* yellow at the base, then ivory-white with reddish-brown specks. On the *outer surface* the color in *C. lowianum* is yellowish white becoming yellowish green at top; in *C. eburneum,* ivory-white; and in the *hybrid,* ivory-white, becoming yellowish green at top.

Comparisons of Microscopic Characters.

Roots.

Transverse sections of the *roots* of *C. lowianum, C. eburneum,* and *C. eburneo-lowianum* made at 1 inch from the tip were examined (Plate 31, figs. 184, 185, and 186). Outermost is the *velamen,* a zone of water-storing tissue developed from the epidermis, and composed of elongated, hexagonal cells with a spiral thread around their walls. This zone varies in width in each plant according to whether or not it is pressed against another surface. The velamen is much wider in *C. eburneum* than in *C. lowianum,* and between the parents in the *hybrid,* but nearer to *C. lowianum* than *C. eburneum.* (Table J 21.)

The *epidermis,* the innermost layer of the velamen, is composed of rather large cells which in *C. lowianum* are very little wider than deep, in fact almost square; in *C. eburneum* and in the *hybrid* they are much deeper than wide. They are larger, however, in the *hybrid* than in *either parent.* (Table J 21.)

Immediately interior to the epidermis is a cylinder of *cortex,* composed of large, open, thin-walled cells. The cortex is much wider in *C. eburneum* than *C. lowianum,* and practically mid-intermediate in width in the *hybrid.* (Table J 21.)

A great number of isolated *sclerosed cells* are present in the cortex of *C. eburneum.* These are entirely absent in *C. lowianum* and present in the *hybrid,* though not in such great number. In *C. eburneum* there are, on the average, 2 of these in a microscopic field; in the *hybrid,* 1.5. The *walls* are slightly thicker in *C. eburneum* than in the *hybrid.* (Table J 21.)

The *endodermis,* the *innermost layer* of the *cortex,* is a ring of oval cells, which in the *hybrid* are exactly mid-intermediate in depth between those of the *parents;* but are in width identical with those of *C. lowianum.* (Table J 21.)

Table J 22.

	C. lowianum.	C. eburneum.	C. eburneo-lowianum.
Width of velamen:	μ	μ	μ
Average width of velamen.........	455.4	669.6	486.
At widest part.....	792.	1,116.	792.
At narrowest part..	118.8	223.2	180.
Width and depth of cells of epidermis:			
Width............	74.2	65.9	81.4
Depth............	68.4	92.5	104.4
Average width of cortex	1,166.	1,843.	1,151.
Thickness of sclerosed walls............	0	7.2 to 9	5.4 to 7.2
Width and depth of cells of endodermis:			
Width............	34.2	31.7	34.2
Depth............	21.6	28.8	25.2

The central *vascular cylinder* is composed of a central zone of pith from which radiate xylem arms, between which are patches of phloem. There are more *phloem patches,* and consequently more *xylem arms,* in *C. eburneum* than in *C. lowianum,* and less in the *hybrid* than in *either parent.*

The number of phloem patches in *C. lowianum* is 16, in *C. eburneum* 18, in *C. eburneo-lowianum* 11.

The *largest vasa* are larger in *C. lowianum* than in *C. eburneum,* and though between the parents in size in the *hybrid* they are nearer *C. eburneum* than *C. lowianum.*

The diameter of the largest vasa in *C. lowianum* is 86.4μ, in *C. eburneum* 57.6μ, in *C. eburneo-lowianum* 68.4μ.

Leaf.

Sections of *upper epidermis* were taken from the apex, middle, and base of leaves of the same age. The cells are almost rectangular with thick walls, and each contains one rod-shaped crystal. At the *apex* and *base* of the leaf the epidermal cells of the *hybrid* are larger than those of *either parent,* but at the *middle* they are exactly mid-intermediate in length, though the same as *C. lowianum* in width. (Table J 23.)

The average length of the *upper epidermal cells* for the *entire leaf* is greater in the *hybrid* than in *either parent,* while the average *width* is exactly *mid-intermediate* between those of the parents.

Sections of the *lower epidermis* were taken from the apex, middle, and base of the leaf. The cells are rectangular and have thick walls like the upper epidermal cells. At the apex and base of the leaf the cells of the *hybrid* are in size between those of the two parents; but at the middle those of the *hybrid* are longer than those of *either parent,* and of the same width as in *C. lowianum.* (Table J 23.)

Table J 23.—*Lengths and widths of upper and lower epidermis of leaves.*

	C. lowianum.	C. eburneum.	C. eburneo-lowianum.
Upper epidermis:	μ	μ	μ
At apex..........	43 by 23.8	47.5 by 24	58.3 by 30.1
At middle.........	38.5 by 21.5	47.5 by 26	43.5 by 21.5
At base...........	43 by 23	47.5 by 23.8	53.5 by 19.3
Average for entire leaf............	41.5 by 22.7	47.5 by 24.6	52 by 23.6
Lower epidermis:			
At apex...........	34 by 21.5	47 by 17	39 by 19
At middle.........	34 by 16	38.5 by 18	45.5 by 16
At base...........	36.5 by 13.	53.8 by 25	43 by 15
Average for entire leaf............	35 by 17	43 by 20	42.5 by 17

The average size of the *lower epidermal cells* for the *entire leaf* in the *hybrid* is between those of the parents; the length, however, is nearer that of *C. eburneum,* in fact almost identical with it, while the width is identical with that of *C. lowianum.*

Stomata are numerous on the *lower epidermis.* At the *apex* and the *base* of the leaf the number in the *hybrid* tends to intermediateness but nearer to *C. eburneum.* At the *middle,* however, there is a less number in the *hybrid* than in *either parent.* On an average for the entire leaf the number in the *hybrid* is equal to that of *C. eburneum* and somewhat less than in *C. lowianum.*

TABLE J 24.—*Number of stomata on lower epidermis in a field.*

	C. lowianum.	C. eburneum.	C. eburneo-lowianum.
At apex	17	21	20
At middle	31	24	22
At base	6	4	5
Average for entire leaf	18	16	16

Transverse sections of the leaf, near the apex, were examined in the region of the midrib (Plate 31, figs. 187, 188, and 189). The *upper epidermis* consists of rounded cells with a thick cuticle on the outer face. The upper epidermis is slightly deeper in *C. eburneum* than in *C. lowianum,* and deeper in the *hybrid* than in *either parent.* The *lower epidermis* also consists of rounded cells with a thick cuticle on their outer face but smaller than the upper epidermal cells. The lower epidermis is deeper in *C. lowianum* than in *C. eburneum* and in the *hybrid,* though between the two, it is nearer the depth of *C. lowianum.* (Table J 25.)

The cells of the layer beneath the upper epidermis, the *aqueous-tissue,* become greatly elongated in the region of the midrib. They are less deep and wider in *C. lowianum* than in *C. eburneum,* and deeper in the *hybrid* than in *either parent* and of the same width as *C. lowianum.* (Table J 25.)

The *midrib* bundle is much larger in *C. lowianum* than in *C. eburneum,* and in the *hybrid* not quite as deep as in *C. eburneum.* The width in the *hybrid* is identical with that of *C. eburneum.* The diameter of the *largest vasa* of the *hybrid* is also identical with that of *C. eburneum.* (Table J 25.)

TABLE J 25.

	C. lowianum.	C. eburneum.	C. eburneo-lowianum.
Depth of cells of upper and lower epidermis at midrib:	μ	μ	μ
Upper epidermis	28	30.1	32.2
Lower epidermis	21.5	15	19.3
Depth and width of elongated cells of aqueous tissue at midrib:			
Depth	56	68.8	94.6
Width	30.1	25.8	30.1
Depth and width of midrib and diameters of largest vasa:			
Depth of midrib bundle	210.7	141.9	137.6
Width of midrib bundle	172	116.1	116.1
Diameter of largest vasa	17.2	21.5	21.5
Depth of cells of upper and lower epidermis midway between the midrib and margin:			
Upper epidermis	21.5	25.8	23.7
Lower epidermis	12.9	21.5	19.4

The resemblance, on the whole, in these transverse sections of the leaf near the apex to *C. eburneum* is much greater than to *C. lowianum.* This relationship is also shown in transverse sections taken at the middle of the leaf, at which point the depth of the *lower epidermis* and the depth and width of the *midrib* are in the *hybrid* identical with *C. eburneum.* The diameter of the largest vasa in the *hybrid* is nearer *C. eburneum* than *C. lowianum.* Only the depth of the *upper epidermis* is identical with *C. lowianum* and the size of the cells of the *layer beneath* the *upper epidermis* is more like that of *C. lowianum* than of *C. eburneum.* (Table J 25.)

Transverse sections near the *apex* were also examined at a point *midway* between the *midrib and the margin.* The *upper epidermis* appears as a layer of rounded oval cells with a thick cuticle on the outer face. It is deeper in *C. eburneum* than in *C. lowianum,* and exactly mid-intermediate in the *hybrid.* The *lower epidermal* cells are oval with a much thicker cuticle on the outer face. These are much deeper in *C. eburneum* than in *C. lowianum,* and though between the two parents in depth in the *hybrid,* yet nearer *C. eburneum.*

Between the two layers of epidermis are layers of rounded oval cells rather closely packed together and very well filled with green chloroplasts. The layer just beneath the *upper epidermis,* the *aqueous-tissue,* is composed of slightly larger cells which do not contain many chloroplasts. There are 12 layers of cells in the *mesophyll* of *C. lowianum,* 10 in *C. eburneum,* and 10 in the *hybrid.*

Running parallel with the midrib and just beneath the upper epidermis and lower epidermis are strands of heavily thickened *sclerenchyma.* Those beneath the *upper epidermis* are much larger than those beneath the *lower epidermis.* Those beneath the upper epidermis are practically circular in *C. lowianum;* deeper than wide in *C. eburneum;* and circular in the *hybrid.* They are smaller in the *hybrid* than in *either parent,* though of the same width as in *C. eburneum.* They are more numerous in *C. eburneum* than in *C. lowianum,* and in the *hybrid* of the same number as in *C. lowianum.* (Table J 26.)

TABLE J 26.

	C. lowianum.	C. eburneum.	C. eburneo-lowianum.
Beneath upper epidermis:	μ	μ	μ
Number in a field	4	6	4
Depth	51.6	64.5	43
Width	51.6	43	43
Beneath lower epidermis:			
Number in a field	4	7	5
Depth	43	51.6	34.4
Width	43	43	34.4

The *sclerenchyma strands* near the *lower epidermis* are also circular in *C. lowianum;* deeper than wide in *C. eburneum;* and circular in the *hybrid.* They are smaller in the *hybrid* than in *either parent.* They are more numerous in *C. eburneum* than in *C. lowianum;* but between the parents in number in the *hybrid,* though nearer *C. lowianum.* (Table J 26.)

FLOWER.

The *upper epidermis* of the *dorsal sepal* in all three plants were examined at the middle point. The cells are pentagonal or hexagonal and have rather thick walls. They are larger in *C. lowianum* than in *C. eburneum,* and shorter in the *hybrid* than in *either parent,* but be-

tween the *parents* in width, though very much nearer *C. eburneum.* (Table J 27.)

The *color* is an olive green with faint brownish lines along the veins in *C. lowianum;* and ivory-white in *C. eburneum;* and a pale yellowish-brownish-green with reddish-brown lines along the veins in the *hybrid.* The color is due to the presence of reddish-violet sap and yellow chromoplasts in the cells in both *C. lowianum* and the *hybrid,* and to very pale, yellowish chromoplasts in *C. eburneum.*

The *lower epidermis* of the *dorsal sepal* was also examined at the median point. The cells are similar to the upper epidermal cells, but do not differ so much in the ratio of length to width. The cells are larger in *C. lowianum* than in *C. eburneum.* In length, the cells of the *hybrid* are between those of the parents, though much nearer *C. lowianum* than *C. eburneum;* in width they are almost identical with those of *C. lowianum.* (Table J 27.)

The *upper epidermis* of one of the *lateral petals* was also examined at the median point. The cells are longer and narrower in *C. lowianum* than in *C. eburneum.* In the *hybrid* the length is almost exactly mid-intermediate between the *parents,* while the width is slightly greater than in *either parent.* (Table J 27.)

The *color* of the *petals* is due to a red-violet sap and yellow chromoplasts in *C. lowianum* and the *hybrid,* and to pale yellowish chromoplasts in *C. eburneum.*

The *lower epidermis* of one of the *lateral petals* was also examined at the *median* point. The cells are longer and narrower in *C. lowianum* than in *C. eburneum.* In the *hybrid* they are almost identical in dimensions with those of *C. lowianum,* being of the same width but of slightly greater length. (Table J 27.)

Sections of the *upper epidermis* of the *anterior lobe of the labellum,* over the colored area are reddish crimson in *C. lowianum;* pale yellow in *C. eburneum;* and brownish red in the *hybrid.* The cells in all three plants are papillose. The papillæ are long, narrow, and pointed in *C. lowianum;* short, wide, and blunt in *C. eburneum;* and of all gradations in length, width, and pointed to blunt tips in the *hybrid,* the average length, however, being nearer *C. lowianum* than *C. eburneum.* (Table J 27.)

The red-crimson of *C. lowianum* and the brownish red of the *hybrid* are due to the epidermal papillæ being filled with small, yellow chromoplasts, and also to some of them containing a reddish-violet cell sap. The yellow of *C. eburneum* is due to the papillæ containing yellow chromoplasts.

Sections of the *lower epidermis* of the *anterior lobe of the labellum* were also examined. The cells are hexagonal in shape and have rather thick walls. They are slightly shorter and wider in *C. lowianum* than in *C. eburneum,* but smaller in the *hybrid* than in *either parent.* (Table J 27.)

The cells of the *upper epidermis* of the *lateral lobe of the labellum* are irregularly pentagonal, hexagonal or rectangular in shape. They are longer and narrower in *C. lowianum* than in *C. eburneum;* shorter in the *hybrid* than in either parent; but between the two parents in width, though nearer *C. eburneum* than *C. lowianum.* (Table J 27.)

TABLE J 27.

	C. lowianum.	C. eburneum.	C. eburneo-lowianum.
Length and width of cells of upper epidermis at middle of dorsal sepal:	μ	μ	μ
Length	93.6	88.9	83.1
Width	64.8	61.2	61.9
Average length and width of cells of lower epidermis at middle of dorsal sepal:			
Length	71.6	65.1	69.5
Width	56.1	47.9	56.5
Length and width of cells of upper epidermis at middle of petal:			
Length	91.8	86.4	89.3
Width	51.1	61.2	62.6
Length and width of cells of lower epidermis at middle of petal:			
Length	84.9	72.7	85.3
Width	51.8	53.6	51.8
Lengths of papillæ on upper epidermis of anterior lobe of labellum	250.2	145.1	231.5
Lengths and widths of cells of lower epidermis of anterior lobe of labellum:			
Length	93.9	94.3	81.3
Width	64.1	63	57.2
Lengths and widths of cells of upper epidermis of lateral lobe of labellum:			
Length	98.3	91.1	88.9
Width	47.5	53.3	51.5
Lengths of papillæ of upper epidermis at lateral lobe of labellum.	527.4	232.5	429.5
Lengths and widths of cells of lower epidermis of lateral lobe of labellum:			
Length	113.7	79.9	101.5
Width	54.7	53.3	59
Lengths and widths of cells of upper (inner) epidermis at base of labellum above band:			
Length	56.1	59.4	55.8
Width	33.1	36	29.9
Lengths and widths of papillæ on crests of inner surface of labellum:			
Length	432	127.4	256.3
Width	54	81	54 to 72
Lengths and widths of cells of inner epidermis at base of column:			
Length	75.6	100.1	60.5
Width	33.1	29.1	27.3

The cells are papillose, the papillæ being long, narrow, and pointed in *C. lowianum;* short, wide, and blunt in *C. eburneum;* and longer and more pointed than in *C. eburneum,* and wider than in *C. lowianum.* In the *hybrid,* the average length is nearer that of *C. lowianum* than of *C. eburneum.* (Table J 27.)

The *color* of the *upper surface* of the *lateral lobes of the labellum* is a very pale yellow, due to the presence

of pale yellow chromoplasts in the upper epidermal cells and papillæ.

On the *lower surface* of the *lateral lobe of the labellum* the cells are longer and wider in *C. lowianum* than in *C. eburneum*. In length the cells of the *hybrid* are between those of the two parents, but nearer *C. lowianum* than *C. eburneum;* but in width they are wider than in *either parent*. (Table J 27.)

On the *inner surface of the labellum* at the *base* of the *wide band* the cells have thick walls and show remarkably well the spaces in the walls between adjoining cells. The cells are smaller in *C. lowianum* than in *C. eburneum,* and smaller in the *hybrid* than in *either parent*. (Table J 27.)

The flat band above referred to rises gradually to form ridges (2 in *C. lowianum* and the *hybrid* and 3 in *C. eburneum*) which end in crests that are yellow in *C. lowianum* and *C. eburnum* and brownish in the *hybrid*. The cells are papillose. The *papillæ* are long and narrow in *C. lowianum;* shorter and wider in *C. eburneum;* and of varying size in the *hybrid,* somewhere near a mean between the *two parents*. There are short wide papillæ in the *hybrid,* but not as short and wide as in *C. eburneum;* and low narrow papillæ, but not as long and narrow as in *C. lowianum*. In the *hybrid* the average length is nearer that of *C. eburneum,* but the width is fairly mid-intermediate between those of the parents. (Table J 27.)

The cells of the *inner epidermis* at the *base* of the *column* are shorter but wider in *C. lowianum* than in *C. eburneum,* and are smaller in the *hybrid* than in *either parent*. (Table J 27.)

Comparative Summary of the Characters of the Hybrid Cymbidium eburneo-lowianum and its Parent-stocks.

The hybrid was found to be:

(1) *The same or practically the same as the seed parent:* In the length of the dorsal sepal; width of the column; width of the endodermal cells on the transverse section of the root; width of the upper epidermal cells at the middle of the leaf; width of the lower epidermal cells at the middle of the leaf; width of the aqueous tissue cells on the transverse section of the leaf at the midrib; number of upper sclerenchyma strands in the transverse section of the leaf halfway between the midrib and the margin; width of the lower epidermal cells of the dorsal sepal; width of the lower epidermal cells of the petals.

(2) *The same or practically the same as the pollen parent:* In the length of the pseudobulbs; width of the old leaves; width of the young leaves; the main color of the inner surface of the column; shape of the epidermal cells on the transverse section of the root; number of stomata on the lower epidermis of the leaf at the apex; the width of the midrib bundle, and the diameter of the largest vessels in the transverse sections of the leaf at the midrib; the number of mesophyll layers, width of the upper sclerenchyma strands in the transverse sections of the leaf halfway between the midrib and the margin; the width of the upper epidermal cells of the dorsal sepal.

(3) *The same or practically the same as both parents:* In the appearance of the roots; diameter of the flower-stalk; shape of the dorsal sepal; length of the lateral sepals; color of the outer surface of the labellum; shape of the upper epidermal cells of the leaf; presence of crystals and thickness of the walls of the upper epidermal cells of the leaf; shape of the lower epidermal cells, and thickness of walls of the lower epidermal cells of the leaf; shape of the upper epidermal cells of the dorsal sepal and the thickness of the walls of the upper epidermal cells of the dorsal sepal; color of the upper surface of the lateral lobes of the labellum.

(4) *Intermediate:* In the amount of drooping of leaves ♂; length of old leaves ♀; length of young leaves ♂; number of leaves to growth; length of flower-stalk ♀; length of bract ♀; length of pedicles ♀; number of flowers; width of dorsal sepal ♀; width of lateral sepals ♀; color of the lower surface of the sepals; background of the upper surface of the sepals; length of the lateral petals; width of the lateral petals ♀; color of the petals; width of the labellum ♀; color of the inner surface of the tube of the labellum; color at tip of crest; color of V mark on anterior lobe of labellum ♀ *; length of column ♂; specks on the inner surface of the column; color of the outer surface of the column; average width of the velamen ♀; width of the cortex, number of sclerosed cells in the cortex ♂; thickness of walls of these sclerosed cells ♂, depth of the endodermal cells, and the diameter of the largest vessels ♂ in the transverse section of the root; length of the upper epidermal cells at the middle of the leaf ♂; length ♀, and width of the lower epidermal cells of the leaf at the apex; length ♀ and width ♀ of the lower epidermal cells of the leaf at the base; number of stomata on the lower epidermis of the leaf at the base; depth of the lower epidermis ♀ on the transverse section of the leaf at the midrib; depth of the upper epidermis, depth of the lower epidermis ♂, and the number of lower sclerenchyma strands ♀ on the transverse section of the leaf halfway between the midrib and margin; length of the lower epidermal cells of the dorsal sepal ♀; length of the upper epidermal cells of the petals; shape of the papillæ and length of the papillæ ♀ and color on the upper epidermis of the anterior lobe of the labellum; width of the upper epidermal cells of the lateral lobe of the labellum ♂; shape of the papillæ, and length of the papillæ ♀ on the upper surface of the lateral lobe of the labellum; length of the lower epidermal cells of the lateral lobe of the labellum ♀; length ♂ and width of the papillæ on the crests.

(5) *Higher than in either parent:* In the color of the lines on the upper surface of the sepals ♀; length of the labellum ♂; width ♀ and the depth ♂ of the epidermal cells on the transverse section of the root; length ♂ and the width ♂ of the upper epidermal cells of the leaf at the apex; length ♂ of the upper epidermal cells of the leaf at the base; length ♂ of the lower epidermal cells of the leaf at the middle; depth of the upper epidermal cells ♀, depth of the aqueous tissue ♂ in the transverse section of the leaf at the midrib; length of the upper epidermal cells of the dorsal sepal ♀; width of the upper epidermal cells of the petals ♂; length of the lower epidermal cells of the petals ♀; width of the lower epidermal cells of the lateral lobe of the labellum ♀.

(6) *Lower than in either parent:* In the number of phloem patches ♀ on the transverse section of the root;

* Macroscopically almost identical with ♀, but microscopically more yellow chromoplasts are present and less red-violet sap.

width of the upper epidermal cells of the leaf at the base ♀; number of stomata at the middle of the leaf on the lower surface ♂; depth of the midrib bundle ♂ on the transverse section of the leaf; depth of the upper sclerenchyma strands ♀, depth ♀, and width ♀=♂ of the lower sclerenchyma strands in the transverse section of the leaf, halfway between the midrib and the margin; length ♀ and width ♂ of the lower epidermal cells on the anterior lobe of the labellum; length ♂ of the upper epidermal cells of the lateral lobe of the labellum; length ♀ and width ♀ of the inner epidermal cells of the labellum above the band; length ♀, and width ♂, of the inner epidermal cells at the base of the column. (Table J 28.)

Table J 28.—*Summary of characters of hybrid-stock as regards sameness, intermediateness, excess, and deficit of development in relation to parent-stocks.*

	Macroscopic.	Microscopic.	Total.
Same as seed parent..........	2	7	9
Same as pollen parent........	4	7	11
Same as both parents.........	5	8	13
Intermediate................	22	27	49
Highest.....................	2	12	14
Lowest......................	0	14	14

4. Macroscopic and Microscopic Characters of Denrobium findlayanum, D. nobile, and D. cybele.

(Plate 32, figs. 190 to 195. Tables J, 29 to 42; I, 4 and Summaries, Chart F 4.)

General Descriptions.

Data for the following descriptions were obtained from Engler (Pflanzenreich, IV, Th. 50, II B 21, 30, 35, 306), Veitch (Manual of Orchidaceous Plants, I, 43, 63, 87) and Sander (Orchid Guide, 70, 73).

Dendrobium findlayanum Parish and Reichb. f. (*Seed Parent*).—Stems jointed, with yellowish-green, compressed, clavate internodes, slender at the base and very much swollen at the nodes. Leaves ovate lanceolate, obliquely emarginate. Bracts small and triangular. Flowers usually in pairs on pale lilac pedicels from short racemes produced from nodes of non-leafy stems; sepals oblong lanceolate; lateral ones at their bases prolonged into a short spur; petals ovate oblong, much broader than the sepals; sepals and petals white, tipped with magenta-pink; labellum clawed with a broad ovate blade that is convolute; apex acute, disk sparsely hairy, orange-yellow at the base, white at the rim, magenta-pink at the extreme tip; column white.

Dendrobium nobile Lindl. (*Pollen Parent*).—Stems jointed, only very slightly wider at the nodes. Leaves ovate, lanceolate, obliquely emarginate. Bracts small. Flowers usually in pairs on short racemes from nodes of non-leafy stems; sepals oblong-lanceolate, lateral ones at their bases prolonged into a short obtuse spur; petals ovate-oblong, wider than the sepals, margin wavy; sepals and petals white, tipped with pale reddish violet; labellum clawed with an obovate-oblong blade that is convolute, apex acute, hairy above and below, deep magenta at base, yellowish white at rim, pale reddish violet at extreme tip; column green.

Dendrobium cybele (*Hybrid*).—Stems jointed with internodes that are slender at the base and slightly swollen at the nodes. Leaves ovate lanceolate, obliquely emarginate. Bracts small. Flowers usually in pairs on short racemes from nodes of non-leafy stems; sepals oblong lanceolate, lateral ones at base produced into a short spur; petals ovate-oblong, broader than sepals, margin faintly wavy; sepals and petals white, tipped with pale reddish violet; labellum clawed with a broadly ovate blade that is convolute; apex acute, less hairy than *D. nobile*, deep reddish violet with a tinge of brown at the base, yellowish white at the rim, pale reddish violet at the extreme tip; column green.

Comparisons of the Macroscopic Characters.

Roots.

Practically identical in both *parents* and *hybrid*. Many slender cylindrical roots are given off from the base of the pseudobulbs.

Stem.

Stems erect or semipendulous and jointed in all three plants. The *joints* are smooth, yellowish green, and club-shaped, very slender at the base and swell out at the nodes where they are slightly compressed in *D. findlayanum*. They are deeply ridged, of a much darker green, and only very slightly thicker at the nodes than at the base in *D. nobile*. They are intermediate in color and ridged in the *hybrid*, but in the amount of swelling at the nodes more like *D. nobile*. The *internodes* are longer in *D. findlayanum* than in *D. nobile*, and they are shorter in the *hybrid* than in either parent. The narrowest part of the internode is much wider in *D. nobile* than in *D. findlayanum* and it is in width intermediate in the *hybrid* but much nearer *D. nobile*. Measurements were made at the second, third, and fourth nodes from top of growths of the preceding year.

Table J 29.—*Length and diameters of internodes and diameters of nodal swellings.*

D. findlayanum: Average length of internode 4.8 cm.; diameter of nodal swellings 1.6 cm.; diameter of internodes, narrowest part 0.4 cm.

D. nobile: Average length of internode 3.2 cm.; diameter of nodal swellings 1.2 cm.; diameter of internodes, narrowest part 0.9 cm.

D. cybele: Average length of internode 2.9 cm.; diameter of nodal swellings 1.2 cm.; diameter of internodes, narrowest part 0.8 cm.

Leaf.

The *leaves* arise at the nodes and consist of an ovate lanceolate lamina and a sheathing *peliole* which is persistent. The *lamina* of *D. findlayanum* is shorter but wider than in *D. nobile*. It is shorter in the *hybrid* than in *either parent* and of the same width as in *D. nobile*. The *petiole* is slightly shorter and much narrower in *D. findlayanum* than in *D. nobile*. It is shorter in the *hybrid* than *either parent* and though in width between the *parents* it is much nearer *D. nobile* than *D. findlayanum*. The sizes of the laminas and petioles are given in Table J 30.

Table J 30.—*Sizes of laminas and petioles.*

D. findlayanum: Length of lamina 8.2 cm.; width 2.6 cm.; length of petiole 2.5 cm.; width 1.5 cm.

D. nobile: Length of lamina 12.1 cm.; width 2.1 cm.; length of petiole 2.6 cm.; width 2.7 cm.

D. cybele: Length of lamina 7.1 cm.; width 2.1 cm.; length of petiole 2.2 cm.; width 2.4 cm.

Flower.

Flowers are borne on short racemes from the nodes of non-leafy stems, usually biflorate. The flower-stalks are borne in the axil of the leaf and break through the petiole. *D. nobile* flowers in March and early April; *D. findlayanum* in early May; and the *hybrid* in early April. Thus the time of flowering in the *hybrid* is nearer that of *D. nobile* than *D. findlayanum.*

The *pedicels* are of nearly the same length in all three plants, but are pale magenta-pink in *D. findlayanum,* green with magenta at the top in *D. nobile,* and distinctly magenta-pink for the whole length, in the *hybrid* deeper in color than in *D. nobile.*

The *sepals* and *petals* are of practically the same size in the three plants, but they differ somewhat in color and in the character of the margin. The *sepals* in *D. findlayanum* are white with a faint reddish-violet tip extending for almost half the length of the sepal. In *D. nobile* they are pale whitish lavender, becoming deeper red-violet, usually a very little darker than in *D. findlayanum,* at the apex in the type. In some varieties the color may be lighter or the whole sepal may be a red-violet. In the *hybrid* they are whitish lavender, with the whole apical half deep red-violet, deeper than the typical color of *D. nobile,* and as deep as the deeper colored varieties of *D. nobile.* The *petals* in all three plants are recurved at the tips, the margin in *D. findlayanum* being very much crinkled; that of *D. nobile,* only slightly wavy; that of the *hybrid,* slightly wavy and somewhat crinkled. The *petals* are white in all three, but only the tip is pale red-violet in *D. findlayanum;* more of the apical region is red-violet and of a darker shade in *D. nobile;* and almost half the petal is of a still deeper shade of red-violet in the *hybrid.* This deeper shade is about the same as that of the more deeply colored varieties of *D. nobile.*

The *labellum* is shorter in *D. findlayanum* than in *D. nobile,* and in the *hybrid* between the parents, though slightly nearer *D. findlayanum.* It is wider in *D. findlayanum* than in *D. nobile,* and exactly mid-intermediate in the *hybrid.*

Table J 31.—*Length and greatest width of labellum.*

D. findlayanum: Length 3.3 cm.; greatest width 2.7 cm.
D. nobile: Length 3.7 cm.; greatest width 2 cm.
D. cybele: Length 3.4 cm.; greatest width 2.3 cm.

The *labellum* is much flatter in *D. findlayanum* than in *D. nobile,* and is fairly mid-intermediate between the parents in the *hybrid.* It has a distinctly acute apex in *D. findlayanum;* none in *D. nobile;* and a distinct apex in the *hybrid,* though not so acute as in *D. findlayanum.*

The *exterior of the basal tubular part of the labellum* is yellow and smooth in *D. findlayanum;* a deep red-violet and hairy in *D. nobile;* and a dull red-violet with a yellowish tinge and apparently smooth in the *hybrid.* The *interior of the basal tubular part* is a greenish yellow and not very hairy in *D. findlayanum;* reddish violet and velvety in *D. nobile;* and reddish violet, but not as red as in *D. nobile,* and velvety in the *hybrid.* Above this area the *labellum* opens out and bends downward, forming a rim which is of a pale yellowish white changing to white with a pale reddish-violet spot at the apex in *D. findlayanum;* yellowish white with a pale reddish-violet apex in *D. nobile;* and a sulphur-yellow with a deeper red-violet apex in the *hybrid.*

The *column* in *D. findlayanum* is greenish white with violet lines on the concave face and a white anther case; in *D. nobile,* green with a red-violet anther case; in the *hybrid,* green, but (not as deep as in *D. nobile* but deeper than in *D. findlayanum*) with deep red-violet rims on the concave anterior side and with a violet and white anther case.

Comparisons of the Microscopic Characters.

Roots.

Transverse sections of the *roots* of *D. findlayanum, D. nobile,* and the *hybrid* (Plate 32, figs. 190, 191, and 192) were made at a half inch from the root tip. Outermost is the *velamen,* a zone of water-storing tissue developed from the epidermis and consisting of several layers of thin-walled, elongated, hexagonal cells with a spiral thread around their walls. The width of this zone varies as the pressure of the root against some other object, but, on the average, it is much narrower in *D. findlayanum* than in *D. nobile,* and in the *hybrid* it is nearer the width of *D. findlayanum* than that of *D. nobile.* (Table J 32.)

The *epidermis,* the innermost layer of the *velamen,* is a layer of rectangular cells much deeper than wide, with thickened walls, especially the outer. The cells are not as deep in the *hybrid* as in the *parents,* and the widths of the three are very nearly the same, that of *D. findlayanum* being less than that of *D. nobile* and the *hybrid.* (Table J 32.)

The *cortex* is a zone of about 6 layers of large, rounded, thin-walled cells. The width varies slightly in the three, but is less in the *hybrid* than in *either parent.* (Table J 32.)

Table J 32.

	D. findlayanum.	D. nobile.	D. cybele.
Widths of velamen:	μ	μ	μ
Average width of velamen	237.6	414	263.2
Widest part	288	450	342
Narrowest part	180	374.4	162
Depth and width of cells of epidermis:			
Depth	40	46.5	38
Width	22.5	24.5	24
Width of cortex	274.5	263	256.5
Depths and widths of cells of endodermis:			
Depth	20.5	23.8	18.7
Width	20.9	25.2	22.7
Diameter of vascular cylinder, number of protoxylem patches, and diameter of largest vasa:			
Diameter of vascular cylinder	522	918	666
Diameter of largest vasa	396	50.4	50.4
Lengths of starch grains	4.5	2.7	7.2
Width and depth of cells of epidermis:			
Width	14.4	23.4	21.6
Depth	9.9	12.6	11.5
Width of cuticle	9 to 10.8	7.2	7.2 to 9
Width and depth of cells of hypodermis:			
Width	21.6	32.4	34.2
Depth	28.8	23.4	30.6

The *endodermis*, the innermost layer of the cortex, is a hollow cylinder of cells which vary in form from rectangular to square, the radial walls of which are thickened. The cells of the *hybrid* are not as deep as those of the *parents*, but in width are almost exactly mid-intermediate between those of the *parents*. (Table J 32.)

The *vascular cylinder, protoxylem patches*, and *largest vasa* vary in the parents and hybrid. The vascular cylinder is larger in *D. nobile* than in *D. findlayanum*, and in the *hybrid* is nearer the size of *D. findlayanum;* there are 21 *protoxylem patches* in *D. nobile*, 12 in *D. findlayanum*, and 16 in *D. cybele*, and the diameter of the *largest vasa* in *D. findlayanum* is less than in *D. nobile* and in the *hybrid*. (Table J 32.)

Stem.

Transverse sections of the stems of the preceding year were made at the third *nodal swelling* from the top. In *D. findlayanum* the tissue is not open, there are large *intercellular spaces*, and the bundles are quite far apart. In *D. nobile* the tissue is not so open, the *intercellular spaces* are much smaller, and the *bundles* are much closer together. In the *hybrid* the tissue is slightly more open than in *D. nobile* and less open than in *D. findlayanum*, the *intercellular spaces* are smaller, and the bundles are closer together than in *either parent*. There is very little *starch* stored in *D. findlayanum* and *D. nobile*, and the grains are quite small. In the *hybrid* there is much more starch, and the grains are larger than in *either parent*. (Table J 32.)

Transverse sections of the stems were also taken at the *third internode* from the top where the stem is narrowest. The cells of the *epidermis* are small with slightly thickened walls on the inner and lateral faces, and a very thick cuticle on the outer face. They are smaller in *D. findlayanum* than in *D. nobile*, and in the *hybrid* while between those of the parents in size they are much nearer *D. nobile*. (Table J 32.)

The cuticle is much deeper in *D. findlayanum* than in *D. nobile*, while in the *hybrid* it is almost exactly mid-intermediate between the *parents*. (Table J 32.)

The *hypodermis* is composed of larger cells, rather irregular in size and shape, those of *D. findlayanum* being narrower than deep; those of *D. nobile* are wider than deep; and those of the *hybrid* are very nearly as deep as wide. The cells of the *hybrid* are larger than *either parent*, the width being slightly greater than in *D. nobile* and the depth slightly greater than in *D. findlayanum*. (Table J 32.)

The *intercellular spaces* are much smaller in *D. findlayanum* than in *D. nobile* and the *hybrid*. Those of the *hybrid* and *D. nobile* are of very nearly the same size. The hybrid is also closer to *D. nobile* in the distribution of bundles. In *D. findlayanum* the bundles are packed close together while in *D. nobile* and in the *hybrid* they are more scattered. The number of bundles in a field (16 mm. objective) is: *D. findlayanum* 30, *D. nobile* 9, *D. cybele* 9.

The *bundles* are composed of an outermost crescent-shaped area of very heavily thickened cells, the *sclerenchyma*, which on three sides surrounds the *phloem*. The *phloem* is a small patch of thin-walled cells just interior to the sclerenchyma. The inner face of the *phloem* is directly next to the *xylem* which is by far the largest zone in the bundle and is composed of open cells with thick walls. The *sclerenchyma* may be the widest part of the bundle in *D. findlayanum* or it may be of the same width as the xylem. In *D. nobile* it is not nearly as wide as the xylem. In the *hybrid* the sclerenchyma and the xylem are practically of the same width. The bundles of *D. nobile* are much larger than those of *D. findlayanum* and the *hybrid*. The depth of the *hybrid* bundle is practically identical with that of *D. findlayanum*, and the width is slightly less than that of *D. findlayanum*. (Table J 33.)

Table J 33.—*Dimensions of sclerenchyma, phloem, xylem, and entire bundle.*

	D. findlayanum.		D. nobile.		D. cybele.	
	Depth.	Width.	Depth.	Width.	Depth.	Width.
	μ	μ	μ	μ	μ	μ
Sclerenchyma....	43.9	119.9	65.9	133.2	42.1	113.4
Phloem.........	40.3	51.1	40.7	61.2	42.1	51.8
Xylem..........	145.8	115.2	217.8	154.4	145.1	114.1
Entire bundle....	230	119.9	324.4	154.4	229.3	114.1

The *largest vasa* of the *hybrid*, though between those of the *parents* in size, are nearer those of *D. nobile* than *D. findlayanum:* 33.5μ for *D. findlayanum*, 40.7μ for *D. nobile*, 38.5μ for *D. cybele*.

Leaf.

Portions of *upper epidermis* were taken from the *apex*, the *middle*, and the *base* of the lamina. The *epidermal* cells are rather hexagonal in shape, with firm walls and a thick cuticle on the outer face. The cell walls are thicker in *D. findlayanum* than in *D. nobile* and are almost as thick in the *hybrid* as in *D. findlayanum*. The cells of *D. nobile* are much larger than those of *D. findlayanum*. Those of the *hybrid* are in size much nearer those of *D. findlayanum*, being on the average a very little larger. (Table J 34.)

Sunken epidermal cells appearing on surface view as thick-walled, circular cells are present on the *upper epidermis*. These are more numerous in the *hybrid* than in *either parent*. (Table J 34.)

Table J 34.

	D. findlayanum.		D. nobile.		D. cybele.	
	Length.	Width.	Length	Width.	Length	Width.
Lengths and widths of upper epidermis at apex, middle, and base of lamina:	μ	μ	μ	μ	μ	μ
At apex......	65.2	50.4	119.2	56.9	69.1	40.7
At middle....	76.3	61.2	108	57.6	75.3	52.9
At base......	72	54	114.1	46	81	46.8
Average size..	71.1	55.2	113.8	53.5	75.1	46.8
Lengths and widths of lower epidermis at apex, middle, and base of lamina:						
At apex......	59.8	53.3	79.9	48.9	57.6	28.8
At middle....	55.4	42.1	66.2	44.3	54.7	37.8
At base......	58.3	38.5	68.8	33.1	64.4	27.9
Average size..	57.8	44.6	71.6	42.1	58.9	31.5

Sections of *lower epidermis* were taken from the same regions, the cells are slightly smaller than those of the upper epidermis, the *sunken cells* are similar in appearance, and there are numerous *stomata.* The *lower epidermal* cells of *D. nobile* are larger than those of *D. findlayanum,* while those of the *hybrid* are, as a rule, smaller than those of *either parent,* except at the base of the lamina where the cells are in length between those of the *parents.* The average size for the entire lamina is much narrower than *either parent* and very slightly longer than in *D. findlayanum.* (Table J 35.)

The *sunken epidermal* cells are more numerous in the *hybrid* than in *either parent,* in which respect it is nearer *D. nobile* in which they are more numerous than *D. findlayanum.* (Table J 35.)

The *stomata* are also more numerous in the *hybrid* than in *either parent,* except at the base of the lamina where they are less numerous. The average number in a field for the entire lamina is greater in *D. findlayanum* than in *D. nobile,* while in the *hybrid* it is greater than in *D. findlayanum.* (Table J 35.)

TABLE J 35.—*The number of stomata in a field on the lower epidermis.*

	D. findlayanum.	D. nobile.	D. cybele.
Number of sunken epidermal cells of upper epidermis in a field at apex, middle, and base of lamina:			
At apex	0.95	0.89	1.88
At middle	0.7	0.78	0.9
At base	.78	1	1.3
Number of sunken epidermal cells of lower epidermis in a field at apex, middle, and base of lamina:			
At apex	1.2	1.7	2.5
At middle	0.56	1.3	1.5
At base	0.53	1.33	1.74
Average number	0.76	1.44	1.91
Number of stomata in a field on lower epidermis:			
At apex	10	6	13.1
At middle	6.2	7.5	11.1
At base	5.2	3.2	3.1
Average number	7.1	5.6	9.1

Transverse sections of the *lamina* (Plate 32, figs. 193, 194, and 195) were made at a point midway between the apex and base, and examined at the midrib. The *upper epidermal* cells directly above the center of the midrib are only slightly elongated, but toward the sides they are greatly elongated, forming a ridge on each side of the midrib. These ridges are larger in *D. nobile* than in *D. findlayanum,* but are not nearly so pronounced in the *hybrid* as they are in the *parents.* The cells have on the inner and lateral faces rather thick walls, while the outer face has a thick cuticle. The cells directly above the center of the midrib are deeper in *D. findlayanum* than in *D. nobile,* while those of the *hybrid* are in depth of a mid-degree of intermediateness between the cells of the *parents.* The cells forming the ridges are more elongated in *D. nobile* than in *D. findlayanum,* while those of the *hybrid* are not elongated nearly as much as in *either parent.* (The statistics are given in Table J 36.)

The *lower epidermis* is a layer of smaller almost square cells with thickened inner and lateral walls and a thick cuticle on the outer wall. These cells are of the same depth in *D. findlayanum* and *D. nobile,* but not quite as deep in the *hybrid* as in the *parents.*

TABLE J 36.

	D. findlayanum.	D. nobile.	D. cybele.
	μ	μ	μ
Depth of upper epidermal cells just above center of midrib	63	54	58.3
Depth of cells forming ridges	98.3	104	67.3
Depth of cells of lower epidermis	36	36	32.4

Between the two epidermal layers is the *midrib bundle,* separated on each side from the epidermis by two layers of mesophyll tissue. It consists of a lowermost, somewhat crescent-shaped area of heavily thickened cells, the *sclerenchyma.* Directly above this is a small patch of thin-walled cells, *phloem* cells, and sieve tubes. Uppermost is a large area of large, open, heavily thickened cells, the *xylem,* in the middle of which there is a small patch of *protoxylem.* The midrib bundle is deeper in *D. findlayanum* than in *D. nobile,* but wider in *D. nobile* than in *D. findlayanum.* In the *hybrid* it is much smaller in both dimensions than in *either parent.* (Table J 37.)

TABLE J 37.

	D. findlayanum.		D. nobile.		D. cybele.	
	Depth.	Width.	Depth.	Width.	Depth.	Width.
	μ	μ	μ	μ	μ	μ
Sclerenchyma	36	198	81.7	223.2	28.8	154.8
Phloem	46.8	64.8	47.5	70.6	34.2	45
Xylem	162	216	153.4	230.4	122.4	168.1
Entire midrib bundle	244.8	216	232.6	230.4	185.4	168.1

Transverse sections of the *leaf* examined at the region of a *bundle* midway between the midrib and the margin show the *upper epidermis* to be a layer of large rectangular cells with lateral and inner walls only slightly thickened, and with a thick cuticle on the outer face. The upper epidermal cells are larger in *D. findlayanum* than in *D. nobile,* and in the *hybrid* are in size between those of the two *parents,* but in depth nearer that of *D. nobile* and in width nearer that of *D. findlayanum.* The *cuticle* on the outer wall is much thicker in *D. nobile* than in *D. findlayanum,* while in the *hybrid* it is not as thick as in the *parents.* (Table J 38.)

TABLE J 38.

	D. findlayanum.	D. nobile.	D. cybele.
	μ	μ	μ
Depth and width of cells of upper epidermis midway between midrib and margin:			
Depth	47.2	44.3	45.4
Width	43.2	26.7	40.3
Depth of cuticle	3.6 to 5.4	5.4 to 7.2	3.6 to 4.5
Depth and width of cells of lower epidermis:			
Depth	47.5	47.9	34.9
Width	46	41.8	37.8
Length of sunken cells of upper and lower epidermis	69.8	75.6	[1]64 [2]76.2

[1]Upper. [2]Lower.

The cells of the *lower epidermis* are rectangular, with a thick *cuticle* on the outer face. In *D. findlayanum* and *D. nobile* they are deeper than wide, while in the *hybrid* they are wider than deep and smaller than in *either parent.*

Stomata are cut in section on the *lower epidermis.* The *sunken epidermal cells* appear cut longitudinally on both lower and upper epidermis. They are rather thick-walled, awl-shaped cells sunken in the epidermis. They are longer in *D. nobile* than in *D. findlayanum,* and shorter in the *hybrid* than in *either parent.*

The *mesophyll* consists of rather closely packed, oval cells which contain numerous plastids and starch grains, with circular intercellular spaces. No palisade cells are present.

The *bundles* have on both sides thickened *sclerenchyma patches,* that on the lower side being much more extensive than that on the upper side. The *phloem,* composed of small, thin-walled cells, is toward the lower epidermis. Above it is the *xylem,* composed of large, open cells with thick walls.

Pieces of the *outer* (lower) *epidermis* were examined from the *upper* (nearest lamina) and *basal* parts of the *petiole* of leaves of the same age. In the *upper* part the *cells* are of practically the same width but longer in *D. nobile* than in *D. findlayanum,* while in the *hybrid* they are longer and narrower than in *either parent.* At the *base* of the *petiole* the cells of *D. findlayanum* are smaller than in *D. nobile,* while in the *hybrid* they are a little longer than in *D. findlayanum* and in width exactly mid-intermediate between the two parents.

The *inner* (upper) *epidermis* of the *petiole* was also examined *near* the *lamina* and at the *base* of the *petiole.* In the upper part the cells of *D. nobile* are larger than those of *D. findlayanum,* while those of the *hybrid* are in length practically identical with those of *D. nobile,* and in width with those of *D. findlayanum.* At the base the cells are longer in *D. nobile* than in *D. findlayanum,* and wider in *D. findlayanum* than in *D. nobile.* Those of the *hybrid* are longer than in *D. findlayanum* and shorter than in *D. nobile,* but slightly nearer *D. findlayanum;* and they are identical in *width* with *D. nobile.* (Table J 39.)

TABLE J 39.

	D. findlayanum.		D. nobile.		D. cybele.	
	Length.	Width.	Length.	Width.	Length.	Width.
Length and width of cells of lower epidermis of petiole:	μ	μ	μ	μ	μ	μ
Nearest lamina	62.3	45	72.4	44.6	73.8	42.5
At base.......	56.5	36.4	72.2	46	61.2	41.4
Length and width of cells of upper epidermis of petiole:						
Nearest lamina	60.8	32	70.5	36.7	70.2	32
At base.......	70.9	36.4	121.7	31	92.5	31.3

Sunken epidermal cells are almost mid-intermediate in number in the *hybrid* at the top of the petiole, and are more numerous than in *either parent* at the base of the petiole. (Table J 40.)

TABLE J 40.—*Numbers of sunken epidermal cells.*

	D. findlayanum.	D. nobile.	D. cybele.
At top........................	0.77	1.4	1.06
At base.......................	1.5	1	1.7

Hairs are present on the *inner surface* of the petiole. The hair cells each consist of a bladder-like, oval cell on a circular basal cell. Two hairs are usually together, sometimes 3 or 4. They are shorter and more numerous in the *hybrid* than in *either parent.*

FLOWER.

Sections were obtained of the *lower epidermis* at the *middle of the lateral sepal.* The cells are somewhat irregularly pentagonal or hexagonal. They are on an average longer and narrower in *D. findlayanum* than in *D. nobile.* In the *hybrid* the length of the cells, while between those of the parents, is nearer that of *D. findlayanum* than of *D. nobile,* and the width is less than in *either parent* and hence also nearer to *D. findlayanum.* (Table J 41.)

Sections of the *upper epidermis* at the *middle of a lateral sepal* were also compared. The cells are irregularly hexagonal and somewhat papillose. They are larger in length and width in *D. findlayanum* than in *D. nobile,* and are smaller in both dimensions in the *hybrid* than in *either parent,* therefore being nearer *D. nobile* than *D. findlayanum.* (Table J 41.)

Sections were made of the *lower epidermis* at the *middle of the lateral petals.* Here also the cells are irregularly hexagonal. They are slightly smaller in both dimensions in *D. findlayanum* than in *D. nobile.* In the *hybrid* the average length of the cells is equal to that of *D. findlayanum,* but the width is less than in *either parent,* thus being closer to *D. findlayanum* rather than *D. nobile.* (Table J 41.)

Sections of the *upper epidermis* at the *middle of a lateral petal* were also examined. The cells are rather irregularly hexagonal or rectangular, and are very slightly papillose. They are larger in both dimensions in *D. findlayanum* than in *D. nobile,* and smaller in the *hybrid* than in *either parent,* therefore being nearer *D. nobile.* (Table J 41.)

Sections of the epidermis were taken from the *outer surface of the labellum* over the colored area. This area is yellow in *D. findlayanum,* red-violet in *D. nobile,* and dull red-violet in the *hybrid.* The cells in *D. findlayanum* are longer and wider than in *D. nobile.* In the *hybrid* they are between the sizes of the parents in length but slightly nearer *D. nobile,* while in width they are much nearer *D. findlayanum.* (Table J 41.)

Hairs are not present in *D. findlayanum.* Long multicellular hairs are in great numbers in *D. nobile.* They consist of 3 to 4 rows of slightly elongated cells. There are a few small, mound-like, multicellular hairs in the *hybrid.* (Table J 41.)

The yellow color in *D. findlayanum* was found to be due to yellowish chromoplasts in the epidermal cells. The violet color of *D. nobile* is due to the presence of deep lavender sap in the layer beneath the epidermis and in the multicellular hairs. Colorless plastids are present in the epidermis and multicellular hairs. The dull red-violet of the *hybrid* is due to the presence of

pale-lavender sap in the cells of the layer beneath the epidermis, and also to yellowish-green chromoplasts in the epidermal cells and hairs.

Sections of the *inner* (*upper*) *epidermis* of the *labellum* over the colored concave area were compared. This area is greenish yellow in *D. findlayanum;* deep reddish violet in *D. nobile;* and deep reddish violet in the *hybrid,* but with less red than in *D. nobile.* Long multicellular hairs are very numerous. They are much shorter in *D. findlayanum* than in *D. nobile,* and in the *hybrid,* while between those of the *parents,* the average length is much nearer *D. nobile* than *D. findlayanum.* (Table J 41.)

TABLE J 41.

	D. findlayanum.	D. nobile.	C. cybele.
Length and width of cells of lower epidermis of middle of lateral sepal:	μ	μ	μ
Length	100.1	87.5	96.8
Width	50.7	57.2	46.4
Length and width of cells of upper epidermis at middle of lateral sepal:			
Length	97.9	96.8	90.7
Width	61.2	54	52.6
Length and width of cells of lower epidermis of middle of lateral petal:			
Length	90	92.9	90
Width	53.6	54.7	52.6
Length and width of cells of upper epidermis of middle of lateral petal:			
Length	104.8	94.3	75.2
Width	62.6	58.3	46.8
Length and width of cells of outer (lower) epidermis of labellum:			
Length	75.7	66.2	70.5
Width	46.4	34.5	44.3
Length of hairs on outer epidermis of labellum	Absent	383.4	70.9
Length of multicellular hairs on upper epidermis over concave colored area of labellum	175.3	306.4	258.8
Length of multicellular hairs on upper epidermis of rim	281.9	498.9	327.2
Length and width of cells of upper epidermis over reddish-violet apex:			
Length	72	61.9	77
Width	47.9	37.4	46.4
Length of multicellular hairs on upper epidermis of labellum over reddish-violet apex	Absent	167	127.4

The greenish-yellow color in *D. findlayanum* is due to the presence of yellow chromoplasts in both epidermal cells and multicellular hair cells. The deep reddish-violet color in *D. nobile* is due to the cells and multicellular hairs being filled with a reddish-violet cell sap. Colorless plastids are also present. The deep reddish-violet color in the *hybrid* (less red than in *D. nobile*) is due to the presence of a deep crimson, with a touch of violet cell sap in the cells and hairs, and also greenish-yellow chromoplasts. The colored plastids appear to give the slightly different shade between *D. nobile* and the *hybrid.* The *hybrid* thus has inherited greenish-yellow chromoplasts from one parent, and a reddish-violet cell sap from the other.

Above, the wide concave part the labellum broadens out and bends slightly downward, forming a *rim.* Sections of the *upper epidermis above this rim* were compared. This area was found to be covered with numerous multicellular hairs containing yellow chromoplasts. These hairs are much shorter in *D. findlayanum* than in *D. nobile,* and in the *hybrid* while between those of the parents the average length is much nearer that of *D. findlayanum* than of *D. nobile.* (Table J 41.)

The color in *D. findlayanum* and *D. nobile* is pale yellow, due to small pale-yellow chromoplasts in the cells and hairs. In the *hybrid,* however, the rim is sulphur-yellow, the chromoplasts being of a darker yellow than in *either parent.*

Sections of the *upper epidermis* of the *labellum* over the *reddish-violet apex* were also examined. The cells are longer and wider in *D. findlayanum* than in *D. nobile.* In the *hybrid* they are longer than in *either parent,* and in width between those of the parents but much nearer to *D. findlayanum.* (Table J 41.)

Multicellular hairs are absent in *D. findlayanum.* They are rather numerous in *D. nobile,* and only a little less numerous in the *hybrid.* The hairs are longer in *D. nobile* than in the *hybrid.* (Table J 41.)

In *D. findlayanum* the color of the apical area is a pale red-violet due to a pale reddish-violet sap in the layer of cells beneath the epidermis. Colorless plastids are present in the epidermal cells. In *D. nobile,* the color is the same as in *D. findlayanum,* and also due to a pale reddish-violet sap in the layer of cells beneath the epidermis. Colorless or very pale greenish-yellow plastids are present in the epidermal cells and hairs. In the *hybrid* the color is of a deeper red-violet than in *either parent,* and is due to a deeper red-violet sap in the layer of cells beneath the epidermis. Colorless or very pale greenish-yellow plastids are present in the epidermal cells and hairs.

COMPARATIVE SUMMARY OF THE CHARACTERS OF THE HYBRID DENDROBIUM CYBELE AND ITS PARENT-STOCKS.

The hybrid was found to be:

(1) *The same or practically the same as the seed parent:* In the smoothness of the external tubular part of the labellum; depth of the bundle on the transverse section of the third internode; width of the upper epidermal cells at the top of the petiole; length of the lower epidermal cells of the petal.

(2) *The same or practically the same as the pollen parent:* In the diameter of the swellings of the stem at the nodes; width of the lamina; color of the external tubular part of the labellum; color of the internal tubular part of the labellum; (*b*) diameter of the largest vessels in the transverse section of the root; size of the intercellular spaces and number of bundles in the transverse section of the third internode of the stem; width of the upper epidermal cells of the leaf at the base; length of the upper epidermal cells at the top of the petiole; width of the upper epidermal cells at the base of the petiole.

(3) *The same or practically the same as both parents:* In the size and appearance of roots; length of the pedicels; size of the sepals; size of petals; width of the epidermal cells on the transverse section of the root;

number of hairs on the concave inner surface of the labellum; number of hairs on the rim of the labellum.

(4) *Intermediate:* In the color of stem; amount of ridging of internodes; amount of swelling at nodes ♂; diameter of the internodes at the narrowest part ♂; width of petiole ♂; flowering period ♂; waviness of margin of petals; length ♀ and width of labellum; depth of labellum; apex of labellum; color of concave face of column; color of anther case; width of velamen ♀; width of endodermal cells ♀, diameter of vascular cylinder ♀, number of protoxylem patches in the transverse section of the roots; character of the tissue at the transverse section of the stem at the third node; width ♂, depth ♂, of the epidermal cells, depth of cuticle, shape of hypodermal cells, comparative widths of sclerenchyma and xylem, and diameter of the largest vessels ♂, on the transverse section of the stem at the third internode; thickness of the cell walls ♀, length ♀, of the upper epidermal cells of the leaf at the apex; length ♀ of the upper epidermal cells of the leaf at the base; length ♂ of the lower epidermal cells of the leaf at the base; depth of the upper epidermal cells above the midrib ♂ in the transverse section of the lamina; depth ♂, width ♀, of the upper epidermal cells on the transverse section of the lamina halfway between the midrib and the margin; length ♀, width of the lower epidermal cells at the base of the petiole; number of sunken epidermal cells at the top of the petiole on the lower epidermis; length of the upper epidermal cells at the base of the petiole ♀; length of the lower epidermal cells of the lateral sepals ♀; length ♂, width ♀, of the lower epidermal cells on the tubular part of the labellum; number of hairs ♀, length of hairs ♀, and color of the outer surface of the tubular part of the labellum; length of hairs ♂, and color of the concave inner surface of the labellum; length of hairs on the rim of the labellum ♂; width of upper epidermal cells ♀, length of hairs ♂, number of hairs ♂, on the upper epidermis of the labellum at the apex.

(5) *Higher than either parent:* In the color of pedicels ♀ = ♂; color of sepals ♂; color of petals ♂; color of rim ♂ and apex ♀ = ♂; of labellum number ♀ = ♂ and size of starch grains ♀ in the transverse section of the stem at the third node; width ♂, and depth ♀, of hypodermal cells in the transverse section of the stem at the third internode; number of sunken epidermal cells on the upper epidermis of the leaf at the apex ♀, at the middle ♂, and at the base ♂; number of sunken epidermal cells on the lower epidermis of the leaf at the apex ♂, at the middle ♂, and at the base ♂; number of stomata on the lower epidermis of the leaf at the apex ♀, and at the middle ♂; length of the lower epidermal cells of the petiole at the top ♂; number of sunken epidermal cells ♀ at the base of the petiole on the lower epidermis; number of hairs ♀, at the top of the petiole on the upper epidermis; number of hairs ♀ at the base of the petiole; color of the chromoplasts ♀ = ♂ in the hairs on the rim of the labellum; length of the upper epidermal cells of the labellum at the apex ♀; color of the sap in the upper epidermal cells of the labellum at the apex ♀ = ♂.

(6) *Lower than either parent:* In the length of internodes ♂; length of lamina ♀; length of petiole ♀; depth of epidermal cells ♀, width of cortex ♂, depth of endodermal cells on the transverse section of the root; size of intercellular spaces ♂, and crowding together of bundles ♂, in the transverse section of the stem at the third node; width of bundles ♀ in the transverse section of the stem at the third internode; width ♀ of the upper epidermis of the lamina at the apex; length ♀, width ♂, of the upper epidermis of the lamina at the middle; length ♀, width ♂, of the lower epidermis of the lamina at the apex; length ♀, width ♀, of the lower epidermis of the lamina at the middle; width ♂ of the lower epidermal cells and number of stomata ♂ at the base of the lamina; depth of the ridges ♀, depth of cells forming the ridges ♀, depth of the lower epidermal cells ♀ = ♂, depth ♂, width ♀, of the midrib bundle in the transverse section of the lamina at the midrib; depth of cuticle ♀, length ♀ = ♂, width ♂, of the lower epidermal cells, length ♂, of the sunken epidermal cells on the transverse section of the leaf halfway between the midrib at the margin; width of the lower epidermal cells at the top of the petiole ♀ = ♂; length of hairs ♂ on the upper epidermis of the petiole; width ♀ of the lower epidermal cells of the lateral sepals; length ♂, width ♂, of the upper epidermal cells of the lateral sepals; width ♀, of the lower epidermal cells of the petals; length ♂, width ♂, of the upper epidermal cells of the petals.

TABLE J 42.—*Summary of characters of hybrid-stock as regards sameness, intermediateness, excess, and deficit of development in relation to parent-stocks.*

	Macroscopic.	Microscopic.	Total.
Same as seed parent..........	1	3	4
Same as pollen parent........	4	6	10
Same as both parents.........	4	3	7
Intermediate.................	13	14	27
Highest......................	5	19	24
Lowest.......................	3	32	35

5. Macroscopical and Microscopical Characters of Miltonia vexillaria, M. rœzlii, and M. bleuana.

(Plate 33, figs. 196 to 198. Tables J, 43 to 49; I, 5 and Summaries. Chart F 5.)

General Descriptions.

Data for the following descriptions were obtained from Veitch (Manual of Orchidaceous Plants, II, 104, 110, 118), Curtis (Botanical Magazine, tables 6037 and 6085), Gardeners' Chronicle, 1889, 203, 749), and Sander (Orchid Guide, 127, 127, 129).

Miltonia vexillaria Nichols (*Seed Parent*).—Pseudobulbs 1 to 1 and a half inches long, ovate-oblong, compressed, bearing 1 leaf at the apex. Leaves 6 to 12 inches long, usually 6 to 8 to 1 growth, distichous and alternate, inclosing the pseudobulb, linear-lanceolate from a narrow sheathing base, darker green above, paler and keeled beneath, the whole plant of a glaucous pea-green color. Racemes usually 2 from the base of each pseudobulb (sometimes more), slender, arching, longer than the leaves, sheaths small, 4 to 7 flowered. Flowers borne on pedicels that are longer than the bracts, largest of the genus, 3 to 4 inches across but variable in size and color; perianth flat; sepals obovate-oblong, subacute or truncate, flat rather recurved, very pale rose; petals similar in shape to the sepals, larger or smaller, deep rose in color, deeper toward the base, and with a broad white margin; labellum suborbicular, 2-lobed in form by

a deep cleft narrowed at the base into a claw and produced into two acute-ovate auricles extending upwards on each side of the column, color is white tinted with pale rose along the veins and at the base a pale yellow streaked with red, 2 small 2-lobed callus at the base that is yellow and prolonged in front into 3 short teeth; column very short.

Miltonia rœzlii Nichols (*Pollen Parent*).—Pseudobulbs 1 to 2 inches long, compressed, ovate-oblong, pale green, bearing 1 leaf at the apex. Leaves 8 to 12 inches long, narrower than in *M. vexillaria,* linear-lanceolate, dark green above, lighter green and keeled beneath. Racemes shorter or as long as the leaves, slender, 2- to 5-flowered. Flowers borne on pedicels that are longer than the bracts, flat, 3 to 3 and a half inches across, variable in size; sepals obovate-oblong, acute, dorsal sepal narrower than the lateral ones, pure white; petals as large as or broader than the lateral sepals, white with a broad red-purple band at the base (the plants used in this research did not have this red-purple band); labellum broadly obcordate with a cleft in the anterior margin and a very acuminate apex in the cleft, clawed at the base and prolonged into 2 small auricles, white with a deep yellow fan-shaped area at the base with red-purple veins; the callus consists of 3 raised lines on the disk with 2 small teeth in front; column longer and wider than in *M. vexillaria.*

Miltonia bleuana (*Hybrid*).—Pseudobulbs 1 to 2 inches long, compressed, ovate-oblong, pale green, bearing 1 leaf at the apex. Leaves linear-lanceolate, dark green above, lighter and keeled beneath. Racemes as long or longer than the leaves, several to 1 growth, 3 to 4-flowered. Flowers borne in pedicels that are longer than the bracts, flat, 3 to 4 inches across, variable in size; sepals obovate-oblong, subacute, slightly truncate, white; petals broader than the sepals and slightly more acute, white with a pink-magenta band at the base; labellum broadly obcordate with a cleft in the anterior margin (not so deep as in *M. vexillaria*) and a short acuminate apex in the cleft, clawed at the base, and prolonged into 2 auricles, white with a fan-shaped rayed red-brown blotch in front of the yellow disk, the callus has 3 ridges with 2 small teeth in front; column short.

Comparisons of the Macroscopic Characters of the Parent and Hybrid Pseudobulbs.

Pseudobulbs.

The pseudobulb in *M. vexillaria* is longer, wider, and thicker than in *M. rœzlii.* In the *hybrid* it is longer and wider than in *either parent,* not quite as thick as in *M. vexillaria* and thicker than in *M. rœzlii.* The pseudobulbs in all three plants are light green and have a waxy covering. (Table J 43.)

Leaf.

The leaves of *M. vexillaria* are longer and broader and are of a paler green than in *M. rœzlii.* The leaves of the *hybrid* vary in length, some being as long as those of *M. vexillaria,* others as short as those of *M. rœzlii,* but the average length and width, though between the two parents, is much nearer *M. rœzlii* than *M. vexillaria.* (Table J 43.)

Table J 43.

	M. vexillaria.	M. rœzlii.	M. bleuana.
Length, width, and thickness of pseudobulbs:	*cm.*	*cm.*	*cm.*
Length	4.7	4.3	5.1
Width	2.5	1.8	2.7
Thickness	1.2	9	1.16
Length and width of leaves of preceding year:			
Length	30.4	22.2	22.5
Width	3.1	1.3	1.9
Length of flower-stalk	13.2	13.7	23.2
Length of pedicel	4	3.9	2.6
Length and width of dorsal and lateral sepals:			
Length of dorsal sepal	2.6	3.4	2.6
Width of dorsal sepal	1.2	1.1	1.2
Length of lateral sepal	2.7	3.6	2.7
Width of lateral sepal	1.1	1.1	1
Length and width of petals:			
Length	2.9	3.3	2.9
Width	1.4	1.3	1.4
Length, width, and cleft of labellum:			
Length of labellum	5.4	4.2	4.2
Width of labellum	5.3	3.8	4.1
Length of cleft	1.8	0.4	0.95
Length and width of column of labellum:			
Length	0.9	1.2	0.9
Width	0.35	0.45	0.4

The color of the leaves of the *hybrid* is very much nearer that of *M. rœzlii* than of *M. vexillaria.*

M. vexillaria has on the average to 1 growth, 7 to 9 leaves; *M. rœzlii,* 4; and the *hybrid,* 6.

Flower.

The *flower-stalk* borne in the axil of one of the leaves at the base of the pseudobulb is practically of the same length in *M. vexillaria* and *M. rœzlii,* but much longer in the *hybrid.* (Table J 43.)

The *pedicel* is shorter in the *hybrid* than in *either parent.* (Table J 43.)

The dorsal and lateral *sepals* are unequal in length, the former being slightly shorter than the latter. The *dorsal sepal* is slightly wider than the *lateral* in *M. vexillaria* and the *hybrid,* but of the same width in *M. rœzlii.* Both dorsal and lateral sepals of *M. vexillaria* are shorter and the dorsal is slightly wider than those of *M. rœzlii,* and they are practically identical in both length and width with those of the *hybrid.* (Table J 43.)

In *M. vexillaria* the sepals are wide and blunt at the apex, with only a small point; in *M. rœzlii* they are acute, the widest part being in the middle, gradually tapering off to a long pointed apex; in the *hybrid* they widen out to a certain extent at the top, but not nearly so much as in *M. vexillaria*, and the apex is longer than in *M. vexillaria,* but shorter than in *M. rœzlii.* They are pale pink in *M. vexillaria*, and white in *M. rœzlii* and the *hybrid.*

The *petals* are shorter and slightly broader in *M. vexillaria* than in *M. rœzlii.* Those of the *hybrid* and *M. vexillaria* are identical in length and width. (Table J 43.)

In shape, the petals somewhat resemble the sepals, but the difference between those of the parents is not so marked. The *hybrid* is fairly mid-intermediate in shape between those of the *parents.*

In color, the petals of *M. vexillaria* are a pale pink-magenta, deeper in tint at the base, and with a white margin; those of *M. rœzlii* are white (typically they have a purple blotch at the base); those of the *hybrid* are white with a pink-magenta blotch at the base, identical or very near the shade at the base of the petal of *M. vexillaria.*

The *labellum* is much longer and wider in *M. vexillaria* than in *M. rœzlii* and the *hybrid.* The length in *M. rœzlii* and the *hybrid* is the same, but the width of the *hybrid* is slightly more. (Table J 43.) All three are *cleft* at the anterior margin, but the cleft in *M. vexillaria* is much longer (one-third of length of labellum) and the angle between the lobes much more acute than in *M. rœzlii,* in which the cleft is one-tenth of length of labellum and the angle between the lobes rather obtuse; while in the *hybrid* the length of the cleft (one-quarter of length of labellum) and the angle are between those of the parents, though in both respects the hybrid is slightly nearer to *M. vexillaria* than to *M. rœzlii.* The angles between the lobes at apex are: *M. vexillaria* 45°, *M. rœzlii* 135°, *M. bleuana* 85°.

At the base of the cleft is an extremely small, pointed apex in *M. vexillaria;* long acuminate in *M. rœzlii;* and longer and more acuminate in the *hybrid* than in *M. vexillaria,* but shorter than in *M. rœzlii.*

The *color* of the labellum at the *base* is lemon-yellow with three deep-red veins at the middle in *M. vexillaria;* a deeper yellow with an orange streak on each side, and with purplish-brown lines, in *M. rœzlii;* a brownish red over the veins and spread out to form a fan-shaped area in the *hybrid.* The rest of the labellum in *M. vexillaria* is magenta-pink except for a white border in front of the yellow area at the base, and deeper pink over the veins. In *M. rœzlii* and the *hybrid* it is pure white.

The *column* is much shorter and narrower in *M. vexillaria* than in *M. rœzlii.* It is the same length in the *hybrid* as in *M. vexillaria,* but in width mid-intermediate between the *parents.* (Table J 43.)

Comparisons of the Microscopic Characters of the Parents and Hybrid.

Pseudobulb.

Sections of the *epidermis* of *M. vexillaria* examined at the middle of the pseudobulb have rectangular or elongated hexagonal cells; very rarely the cells are wider than long. In *M. rœzlii* the cells are less regular in shape; short and wide cells are as frequent as long and narrow ones. In the *hybrid* the cells are more often short and wide than long and narrow. If the long and narrow cells of the three plants be compared, it will be found that the length and width of the cells in the *hybrid* lie between those of the *parents,* but the length is much nearer that of *M. rœzlii* while the width is slightly nearer that of *M. vexillaria.* (Table J 44.)

If the cells of *M. vexillaria* be compared with the short and broad cells of *M. rœzlii* and the *hybrid,* it will be found that the length of the hybrid cells lies between those of the *parents,* but nearer to *M. rœzlii,* while the width is greater in the *hybrid* than in *either parent.* (Table J 44.)

Comparing all the cells, we find that the average length in the *hybrid* lies between those of the *parents,* but very much nearer *M. rœzlii,* while the average width in the *hybrid* is greater than that of *either parent.* (Table J 44.)

The *cell walls* are rather thick in all three. The outer face of the epidermis is covered with wax.

Transverse sections of the pseudobulbs were taken at the median point. Outermost, is a layer of oval epidermal cells with a thick outer wall. These cells are longer and deeper in *M. vexillaria* than in *M. rœzlii.* In length the *hybrid* is nearer to *M. vexillaria,* while in width it is nearer *M. rœzlii.* The *outer wall* is thicker in *M. vexillaria* than in *M. rœzlii,* and in the *hybrid,* while between the parents, it is much nearer the thickness of *M. vexillaria* than that of *M. rœzlii.* (Table J 44.)

Table J 44.

	M. vexillaria.	M. rœzlii.	M. bleuana.
Length and width of long and narrow cells of epidermis of pseudobulbs:	μ	μ	μ
Length	73.4	49.2	55.4
Width	47.5	34.5	41.4
Length and width of short and broad cells of epidermis of pseudobulbs:			
Length	73.4	34.9	41.7
Width	47.5	41.4	52.2
Length and width of cells of epidermis of pseudobulbs:			
Length	73.4	42.5	47.5
Width	47.5	37.8	47.9
Length and depth of cells of epidermis at middle of pseudobulb and thickness of outer wall:			
Length	34.9	29.1	32.7
Depth	24.8	16.9	19.1
Thickness of outer wall	4.3	3.2	4
Length and width of bundles in pseudobulb:			
Length	345.6	201.6	212.4
Width	216	108	162

Within the epidermis are a few rows of rather small cells (containing chloroplasts) which gradually become larger toward the center of the pseudobulb. These cells have thin walls, store mucilage, and have large intercellular spaces. In this tissue the vascular bundles are embedded, the cells around them being smaller and storing a small amount of starch.

The *bundles* are very similar in all three, except that the sheath in *M. vexillaria* is much larger proportionally on both sides than in the *other parent* and the *hybrid.* The bundles consist outermost of a sheath of sclerenchyma tissue, and then in order inward of a patch of *phloem,* a few *xylem vessels,* another small patch of *phloem,* and then the inner part of the sclerenchyma sheath. They are larger, as a whole, in *M. vexillaria* than in *M. rœzlii.* In the *hybrid* in length they are between the parents but much nearer *M. rœzlii,* but in width exactly mid-intermediate between the parents. The bundles measured were those at the same distance proportionally on the longitudinal axis from the ends. (Table J 44.)

Leaf.

Sections of both *upper* and *lower epidermis* from the apex, middle, and base of leaves borne at the top of the

pseudobulb of the preceding year were examined. The *upper epidermal cells* are somewhat rectangular in shape and have a bar-shaped crystal in each cell, and the exterior face is covered with wax. At the apex the cells of *M. vexillaria* are of the same size as those of *M. rœzlii;* at the middle, smaller than *M. rœzlii;* and at the base, larger than *M. rœzlii.* In average size the cells of the entire leaf of *M. vexillaria* are shorter and wider than those in *M. rœzlii.* In the *hybrid* the cells at the apex and middle are shorter, but wider, than in *either parent;* and at the base, a little shorter than in *either parent,* but in width between the *parents,* though nearer *M. vexillaria.* The average size of the cells of the entire leaf of the *hybrid* is shorter and slightly wider than in *either parent.* (Table J 45.)

TABLE J 45.

	M. vexillaria.		M. rœzlii.		M. bleuana.	
	Length.	Width.	Length.	Width.	Length.	Width.
Length and width of cells of upper epidermis of leaf:	μ	μ	μ	μ	μ	μ
At apex......	68	32	68.4	32	56.2	33.1
At middle....	59.8	30.9	68.7	31.3	57.6	31.7
At base......	64.1	33.8	60.1	28.8	59.8	33.1
Average for entire leaf....	63.9	32.2	65.4	30.7	57.9	32.6
Length and width of cells of lower epidermis of leaf:						
At apex......	50	23.8	54.7	19.8	52.9	23
At middle....	52.5	22.3	52.9	19.1	58.3	21.6
At base.......	53.6	27	48.9	24.1	48.2	26.3
Average for entire leaf....	51	24.4	52.2	21	53.1	23.6

Hairs, composed of thin-walled bladder-like cells on thickened basal cells that appear circular on surface view, are present on the upper epidermis but they are not numerous. They are present at the apex and base of the leaf, but not at the middle. They are more numerous in *M. vexillaria* than in *M. rœzlii,* and are less numerous in the *hybrid* than in *either parent.* (Table J 46.)

TABLE J 46.—*Number of hairs in upper epidermis of the leaf in a microscopic field.*

	At apex.	At base.
M. vexillaria.........	1 in 16	1 in 14
M. rœzlii............	1 in 22	1 in 17
M. bleuana...........	1 in 37	1 in 28

The *lower epidermal cells* have slightly wavy walls. At the apex and middle the cells of *M. vexillaria* are shorter and wider than those of *M. rœzlii;* at the base longer and wider. The average size of the cells of the entire leaf of *M. vexillaria* is slightly shorter and wider than in *M. rœzlii.* The cells of the *hybrid* are, at the apex, between those of the length and width, but nearer *M. rœzlii* in length and nearer *M. vexillaria* in width. At the middle they are longer than in *either parent* and nearer *M. vexillaria* in width. At the base, they are shorter than in *either parent* and nearer *M. vexillaria* in width. They are, on an average for the entire leaf, longer than in *either parent* and in width nearer *M. vexillaria.* (Table J 45.)

Stomata are present on the under surface. At the apex and middle of the leaf they are more numerous in *M. vexillaria* than in *M. rœzlii* but less numerous in the *hybrid* than in *either parent.* At the base of the leaf they are less numerous in *M. vexillaria* than in *M. rœzlii,* and in the *hybrid* the number is exactly mid-intermediate between those of the parents.

TABLE J 47.—*Number of stomata in a field on lower epidermis of leaf.*

	M. vexillaria.	M. rœzlii.	M. bleuana.
At apex........	13.4	12	9.8
At middle......	13.7	11.4	10.1
At base........	0.4	2.6	1.5

Transverse sections of leaves of the *two parents* and the *hybrid* were taken at the middle of the leaf. These were examined at the *midrib* region (Plate 33, figs. 196, 197, 198). The leaf has a more elongated *keel* in *M. vexillaria* than in *M. rœzlii.* The keel of the hybrid is intermediate between those of the parents though it resembles that of *M. rœzlii* more than that of *M. vexillaria.* (Table J 48.)

The *angle at the midrib* between the halves of the *lamina* is less acute in *M. vexillaria* than in *M. rœzlii,* and is very fairly mid-intermediate in the *hybrid.*

At the midrib angle the *upper epidermal* cells become narrower and elongated. These are a little deeper and wider in *M. vexillaria* than in *M. rœzlii,* and deeper and wider in the *hybrid* than in *either parent.* (Table J 48.)

The 3 layers of cells beneath the upper epidermis, the *aqueous tissue,* are also elongated at the midrib. These do not contain chlorophyll. The *upper layer* of cells beneath the upper epidermis is more elongated in *M. vexillaria* than in *M. rœzlii,* and in the *hybrid* is of about the same depth as that of *M. rœzlii.* (Table J 48.)

Beneath the third layer of elongated cells is the *midrib bundle* which is larger and approaches an oval form in *M. vexillaria,* while in *M. rœzlii* it is almost as broad as it is deep. The bundle in the *hybrid* is oval and a little smaller than in *M. vexillaria,* and is between the parents in size, but in depth nearer *M. vexillaria* and in width nearer *M. rœzlii.* (Table J 48.)

Uppermost on the bundle is an area of thick-walled open cells, the *xylem,* which is deeper in the *hybrid* than in *either parent.* Below this is a patch of small, thin-walled cells, the *phloem,* which in size is very nearly mid-intermediate between the *parents,* it being a little nearer *M. vexillaria.* Below this is an area of thick-walled cells, the *bundle sheath,* which is not so deep in the *hybrid* as in the *parents.* (Table J 48.)

On each side of the midrib bundle and beneath it are rounded, typical, spongy mesophyll cells filled with chloroblasts. These extend to the aqueous tissue layer beneath the lower epidermis which does not contain chloroplasts. The cells of this layer are of practically the same size in *both parents,* but are smaller in the *hybrid.* (Table J 48.)

The *lower epidermal* cells at the midrib are small and have a thick outer wall. These cells are larger in *M. vexillaria* than in *M. rœzlii,* and smaller in the *hybrid* than in *either parent.* (Table J 48.)

The *transverse sections of the leaves* of the parents and the *hybrid* were compared at the region of the *first main vein from the midrib.* The *upper epidermal* cells are rectangular and have a thick outer wall. They are larger in *M. vexillaria* than in *M. rœzlii.* The cells in the *hybrid* are identical in depth with those of *M. rœzlii,* but in width they are between those of the two parents, but much nearer *M. rœzlii.* (Table J 48.)

Beneath the upper epidermis are three layers of large open cells, containing no chlorophyll, the *aqueous tissue.* The cells of the *first layer* are larger than those of the others. They are smaller in *M. vexillaria* than in *M. rœzlii* and smaller in the *hybrid* than in *either parent.* (Table J 48.)

The *lower epidermis* consists of cells that are very little wider than deep and that have a very thick outer wall. These are wider and less deep in *M. vexillaria* than in *M. rœzlii,* and are smaller in both dimensions in the *hybrid* than in *either parent.* (Table J 48.)

Just beneath the lower epidermis is a layer of *aqueous* tissue, the cells of which are wider but less deep in *M. vexillaria* than in *M. rœzlii.* The cells in the *hybrid* are wider than in *either parent,* but in depth between those of the parents, although less near *M. vexillaria* than *M. rœzlii.* (Table J 48.)

Between the upper and lower areas of aqueous tissue are small rounded cells that contain chlorophyll and starch grains, and having intercellular spaces and strands of fibrous tissue among them. In this tissue are embedded the bundles. The first main bundle from the midrib of *M. vexillaria* is much shorter and narrower than that of *M. rœzlii,* while that of the *hybrid* is between the *parents* in depth, though much nearer to that of *M. vexillaria* but identical with that of *M. vexillaria* in width. (Table J 48.)

FLOWER.

Sections of the *upper epidermis* at the *middle* of the *dorsal sepal* were examined. The cells are papillose in *M. vexillaria,* flat or only very slightly papillose in *M. rœzlii,* and papillose in the *hybrid* though the papillæ are not so long as in *M. vexillaria.* The cells are larger in *M. vexillaria* than in *M. rœzlii,* and smaller in the *hybrid* than in *either parent.* (Table J 48.)

A pinkish-lavender sap is present in the upper epidermal cells of *M. vexillaria,* but absent in *M. rœzlii* and the *hybrid.*

Hairs are very rare in *M. vexillaria,* but comparatively numerous in *M. rœzlii* and the *hybrid,* especially in the latter—in *M. vexillaria* 1 gland in 70 fields, in *M. rœzlii* 1 in 5, in *M. bleuana* 1 in 1½ fields. Each hair is composed of an elongated, thimble-like, very thin-walled cell at the end, then a somewhat awl-shaped cell with slightly thicker walls, at the base of which is a cell that appears circular and thick-walled on surface view. In a few cases two of these hairs appear together, arising from the same cell or adjacent basal cells found in *M. vexillaria* over an area of 65 microscopic fields. They were longer than in *M. rœzlii.* They are more numerous in the *hybrid* than in *either parent,* and are between the parents in length, being a little nearer *M. vexillaria* than *M. rœzlii.* (Table J 48.)

The *lower* epidermal cells are flat and hexagonal in shape. They are larger in *M. vexillaria* than in *M. rœzlii,* and while between the two in the *hybrid* they are less nearer *M. vexillaria* than *M. rœzlii.* (Table J 48.)

Stomata are present on the lower surface, and they are more numerous in *M. vexillaria* than in *M. rœzlii.* The number of stomata in a microscopic field in the *hybrid* is identical with that in *M. vexillaria.* (Table J 48.)

The numbers of *stomata* on the lower epidermis of the *dorsal sepal* is: *M. vexillaria* and *M. bleuana* 0.4 in a field, *M. rœzlii* 0.2 in a field.

Sections of the *upper epidermis* of one of the *lateral petals* were examined. The *cells* in *both parents* and *hybrid* are papillose. They are larger in *M. vexillaria* than in *M. rœzlii.* In the *hybrid* they are in length shorter than in *either parent,* but in width between the *two parents,* although much nearer *M. rœzlii.* (Table J 48.)

The *upper epidermal cells* at the *middle of the petal* of *M. vexillaria* contain a pale pinkish-lavender cell sap which gives the same hue to the petal. Colored sap is not present in *M. rœzlii* or the *hybrid.*

Hairs similar in appearance to those on the upper surface of the dorsal sepal are present on the *upper surface* of the *lateral petals.* They are much less numerous and shorter in *M. vexillaria* than in *M. rœzlii.* In the *hybrid,* they are as numerous as in *M. rœzlii,* and they are longer than in *either parent.* (Table J 48.) These are 1 in 7 fields in *M. vexillaria,* 1 in 2.2 fields in *M. rœzlii,* 1 in 2.2 fields in *M. bleuana.*

The *lower epidermal* cells of the *lateral petal* (at middle) are much larger in *M. vexillaria* than in *M. rœzlii.* In the *hybrid* they are between those of the two parents in length, but slightly nearer *M. vexillaria;* and in width they are almost exactly mid-intermediate between those of the *parents.* (Table J 48.)

The *stomata* are very rare, but less rare in *M. vexillaria* than in *M. rœzlii.* The number in *M. vexillaria* is 1 in 13 fields, in *M. rœzlii* 1 in 27, in *M. bleuana* 1 in 16.

Sections were examined of the *upper epidermis* of the labellum at the *base* above the bright lemon-yellow area in *M. vexillaria,* the orange-yellow area in *M. rœzlii,* and the brownish-red area in the *hybrid.* The color was found to be due to a large globular cluster of orange-yellow chromoplasts together with a few isolated ones in each epidermal cell of *M. vexillaria;* to bright orange globular clusters of chromoplasts in *M. rœzlii;* and to yellow globular clusters of chromoplasts and a reddish-violet cell sap in the *hybrid.* In *M. vexillaria* there is present at the anterior part of the yellow basal area three deep-red veins, the color being due to a pink-magenta cell sap and orange chromoplasts in the upper epidermal cells. In *M. rœzlii* the orange-colored area has a few dull reddish-brownish-purple streaks which are due to the purplish sap and the orange-brown chromoplasts in the upper epidermal cells. In the *hybrid* the color above the veins appears to be spread out over the yellow area, giving the entire colored portion a brownish-purplish-red hue which is due to the yellow chromoplast clusters and the reddish-violet sap in the upper epidermal cells.

The *upper epidermal cells* are papillose, the papillæ being rather long in *M. vexillaria,* short in *M. rœzlii,* and both long and short in the *hybrid.* The average length in the *hybrid* is much nearer *M. rœzlii* than *M. vexillaria.* The cells themselves (basal boundaries measured) are shorter and wider (the width almost equalling the length) in *M. vexillaria* than in *M. rœzlii,* in which latter

TABLE J 48.

	M. vexillaria.	M. rœzlii.	M. bleuana.
	μ	μ	μ
Thickness of leaves at midrib	1,065.6	601.2	716.4
Depth and width of cells of upper epidermis at midrib angle:			
Depth	30.9	28.8	37.1
Width	19.8	16.2	21.6
Depth of cells of first layer of aqueous tissue beneath upper epidermis	144 to 180	108 to 144	108 to 126
Depth and width of midrib bundle:			
Depth	288	198	266.4
Width	216	180	194.4
Relative depth of xylem, phloem, and lower part of sheath of midrib bundle:			
Xylem	176.4	122.4	183.6
Phloem	64.8	39.6	54
Lower part of sheath	46.8	36	28.8
Depth and width of cells of lower aqueous tissue layer beneath lower epidermis:			
Depth	18.7	18.7	17.3
Width	22.3	23	20.5
Depth and width of cells of lower epidermis at midrib:			
Depth	21.2	16.2	14.4
Width	17.6	15.8	15.5
Depth and width of cells of upper epidermis:			
Depth	16.9	16.2	16.2
Width	32.4	28.4	29.9
Depth and width of cells of aqueous layer beneath upper epidermis:			
Depth	34.9	48.9	33.8
Width	53.3	57.9	46.4
Depth and width of cells of lower epidermis:			
Depth	14.8	15.1	12.9
Width	19.4	18	17.3
Depth and width of cells of aqueous tissue beneath lower epidermis:			
Depth	18	22	21.2
Width	26.6	24.8	27.4
Depth and width of first main bundle of midrib:			
Depth	190.8	288	198
Width	126	151.2	126
Length and width of cells of upper epidermis at middle of dorsal sepal:			
Length	100.1	88.2	79.9
Width	73.8	62.3	57.9
Length and width of cells of lower epidermis of dorsal sepal:			
Length	88.6	68.7	75.6
Width	61.6	50.4	52.6
Length and width of cells of upper epidermis of middle of lateral petal:			
Length	106.2	87.1	84.9
Width	70.6	57.6	59.4
Length of hairs of middle of lateral petal	122.4	131	154.8
Length of hairs of upper epidermis of dorsal sepal	147.6	131	143.6
Length and width of cells of lower epidermis of middle of lateral petal:			
Length	91.1	67	81.7
Width	60.8	52.5	56.9

TABLE J 48.—*Continued.*

	M. vexillaria.	M. rœzlii.	M. bleuana.
	μ	μ	μ
Length and width of cells of upper epidermis and length of papillæ at base of labellum:			
Length of cells	69.5	92.2	67.3
Width	61.9	60.1	44.6
Average length of papillæ	111.6	77	79.2
Lengths of hairs on upper epidermis of base of labellum	100.8	105.5	163.4
Length and width of cells and length and number of hairs of upper epidermis at middle of one lobe of labellum:			
Length of cells	78.8	69.5	59.7
Width of cells	60.5	55.6	46.8
Length of hairs	162	144	183.6
Length and width of cells of lower epidermis at middle of labellum:			
Length	105.5	90.7	97.9
Width	77.4	62.6	56.5

they are distinctly long and narrow. In the *hybrid* the cells are smaller than in *either parent*, but in the proportion of length to width they are almost mid-intermediate between the two *parents*. (Table J 48.)

Hairs like those on the sepals and petals are present on the *upper epidermis* at the *base* of the labellum. They are very rare, but less rare in the *hybrid* than in *either parent*—1 in 25 fields in *M. vexillaria,* 1 in 20 fields in *M. rœzlii,* 1 in 2⅓ fields in *M. bleuana.*

These hairs are slightly shorter in *M. vexillaria* than in *M. rœzlii,* and longer in the *hybrid* than in *either parent.* (Table J 48.) The number is, 1 to 2.2 fields in *M. vexillaria,* 1 in 2.0 fields in *M. rœzlii,* 1 in 2.33 fields in *M. bleuana.*

Sections of the *upper epidermis* of the *labellum* were examined at the *middle* of one of the *lobes.* The cells are papillose in all three plants, and larger in *M. vexillaria* than in *M. rœzlii,* but smaller in the *hybrid* than in *either parent.* (Table J 48.)

The average number of hairs in a field for *M. vexillaria* is 1 in 50 fields; for *M. rœzlii* 1 in 20 fields; for *M. bleuana* 1 in 17 fields.

Sections of the *lower epidermis* of the labellum were examined at the *middle* of the labellum. The cells of *M. vexillaria* are larger than those of *M. rœzlii,* while those of the *hybrid* are almost exactly mid-intermediate in length, but are narrower than in *either parent.* (Table J 48.)

Stomata are present on the *lower epidermis:* In *M. vexillaria* 1 in 18 fields; in *M. rœzlii* 1 in 30 fields; and in the *hybrid* 1 in 6 fields.

COMPARATIVE SUMMARY OF THE CHARACTER OF THE HYBRID MILTONIA BLEUANA AND ITS PARENT-STOCKS.

The hybrid was found to be:

(1) *The same or practically the same as the seed parent:* In the thickness of the pseudobulb; length and width of the dorsal sepal; length of lateral sepal; length and width of petals; color of base of petal; length of column; width of bundle in the transverse section of

the leaf at the first main vein; number of stomata on the lower epidermis of the dorsal sepal at the middle.

(2) *The same or practically the same as the pollen parent:* In the length of the leaves; color of the sepals; color of the upper part of the petal; length and width of the labellum; color of the labellum except at base; depth of the first layer of the aqueous tissue beneath the upper epidermis in the transverse section of the leaf at the midrib; depth of the upper epidermal cells on the transverse section of the leaf at the first main vein; color of the upper epidermis at the middle of the dorsal sepals (micro); color of upper epidermis at the middle of the lateral petal (micro); number of hairs on the upper epidermis of the lateral petal at the middle.

(3) *The same or practically the same as both parents:* In the width of the lateral sepals; thickness of the cell walls of the epidermis of the pseudobulb; the shape of the upper epidermal cells of the leaf and the presence of the crystals in the upper epidermal cells of the leaf; shape of the lower epidermal cells of the leaf; shape of the upper epidermal cells on the transverse section of the leaf at the first main vein; shape of the lower epidermal cells of the dorsal sepal at the middle; shape of the upper epidermal cells of the lateral petals at the middle; shape of the upper epidermal cells of the labellum at the middle of one lobe.

(4) *Intermediate:* In the width of the leaves ♂, color of leaves ♂; number of leaves to one growth; shape of sepals; shape of petals; length of cleft in comparison with the length of the labellum ♀; angle between the lobes of the labellum ♀; length of apex of the labellum; width of the column; length of epidermal cells of the pseudobulb ♂; length ♀, and depth ♂, of the epidermal cells, thickness of the outer walls of the epidermal cells ♀, length ♂ and width of bundles in the transverse section of the pseudobulb; width of the upper epidermal cells at the base of the leaf ♀; length ♂ and width ♀ of the lower epidermal cells at the apex of the leaf; width ♀ of the lower epidermal cells at the middle of the leaf; width ♀ of the lower epidermal cells at the base of the leaf; number of stomata on the lower epidermis of the leaf at the base; thickness of the leaf section at the midrib ♂, the angle formed between the two halves of the lamina at the midrib; the depth ♀, and width ♂, of the midrib bundle in the transverse section of the leaf; width of the upper epidermal cells ♂, depth of the lower aqueous tissue cells ♂, depth of the bundle ♀ on the transverse section of the leaf at the first main vein; papillæ on the upper epidermis of the dorsal sepal at the middle; length of the hairs ♀ on the upper epidermis of the dorsal sepal at the middle; length ♂, and width ♂, of the lower epidermal cells of the dorsal sepal at the middle; width ♂ of the upper epidermal cells at the middle of the lateral petals; length ♀ and width of the lower epidermal cells at the middle of the lateral petals; number of stomata ♀ on the lower epidermis at the middle of the lateral petals; color of the sap in the upper epidermal cells at the base of the labellum; length of the papillæ ♂ and shape of the cells of the upper epidermis at the base of the labellum; length of the lower epidermal cells at the middle of the labellum.

(5) *Higher than in either parent:* In the length ♀ and width ♀ of pseudobulbs; length of the flower-stalk ♀ = ♂; color at the base of the labellum ♂; width of the epidermal cells of the pseudobulb ♀; width of the upper epidermal cells of the leaf at the apex ♀ = ♂; width of the upper epidermal cells of the leaf at the middle ♂; length of the lower epidermal cells of the leaf at the middle ♀ = ♂; depth ♀, and width ♂, of the upper epidermal cells on the transverse section of the leaf at the midrib; width ♀ of the lower aqueous tissue in the transverse section of the leaf at the first main vein from the midrib; number of hairs ♂ on the upper epidermis of the dorsal sepal at the middle; length of hairs ♂ on the upper epidermis of the lateral petal at the middle; the extent of the red-violet sap at the base of the labellum ♀ = ♂; number of hairs ♂, length of hairs ♂, on the upper epidermis of the labellum at the base; number of hairs ♂ and length of hairs ♀ on the upper epidermis of the labellum at the middle of one lobe; number of stomata ♀ on the lower epidermis at the middle of the labellum.

(6) *Lower than in either parent:* In the length of the pedicels ♀ = ♂; length of the upper epidermal cells at the apex of the leaf ♀ = ♂; length of the upper epidermal cells at the middle of the leaf ♀, length of upper epidermal cells at the base of the leaf ♀, number of hairs at the apex of the leaf on the upper epidermis ♂; number of hairs at the base of the leaf on the upper epidermis ♂; length of the lower epidermal cells at the base of the leaf ♂; number of stomata at the apex of the leaf on the lower epidermis ♂; number of stomata at the middle of the leaf on the lower epidermis ♂; depth ♀ = ♂, and width ♀, of the cells of the lower aqueous tissue, depth ♂, and width ♂, of cells of the lower epidermis in the transverse section of the leaf at the midrib; width ♀, and depth ♀, of the cells of the first layer of the upper aqueous tissue, width ♂, and depth ♀, of the cells of the lower epidermis on the transverse section of the leaf at the first main vein; length ♂, width ♂, of the upper epidermal cells of the dorsal sepal at the middle; length of the upper epidermal cells at the middle of the lateral petals ♂; length ♀, and width ♂, of the upper epidermal cells at the base of the labellum; length ♂, width ♂, of the upper epidermal cells of the labellum at the middle of one lobe; the width of the lower epidermal cells of the labellum at the middle ♂. (Table J 49.)

Table J 49.—*Summary of characters of hybrid-stock as regards sameness, intermediateness, excess, and deficit of development in relation to parent-stocks.*

	Macroscopic.	Microscopic.	Total.
Same as seed parent	8	2	10
Same as pollen parent	6	5	11
Same as both parents	1	8	9
Intermediate	9	31	40
Highest	4	15	19
Lowest	1	24	25

6. Macroscopic and Microscopic Characters of Cypripedium spicerianum, C. villosum, C. lathamianum, and C. lathamianum inversum.

(Plate 34, figs. 202 to 207. Tables J, 50 to 57; I, 6 and Summaries, Chart F 7.)

General Descriptions.

Data for the following descriptions were obtained from Reichenbach (Gardeners' Chronicle, 1888, 106; and 1854, 135), Veitch (Manual of Orchidaceous Plants, II, 46, 54, 88), Sander (Orchid Guide, 44, 45, 51), Curtis

(Botanical Magazine, Table 6490), Engler (Pflanzenreich, IV, Th. 50, 72, 76, 101; The Garden, 1890, 166; and Gartenflora, 1889).

Cypripedium spicerianum Reichb.f. (*Seed Parent*).—Roots arise from a short stout rhizome. Leaves persistent, distichous and alternate narrowly linear-oblong, bifid at the apex, keeled beneath, dark green above and spotted with dull purple on the under side toward the base, about 5 leaves to 1 growth, the first leaf somewhat shorter and the last very much shortened and erect, inclosing the base of the flower-stalk. Flower-stalk slender, erect, dark brownish-red purple, pubescent, bearing 1 flower; bract linear-oblong, compressed, green, streaked with purple dots, sheathing the red-purple pubescent ovary to about half its length. Flowers erect; dorsal sepal very large, broadly obcordate, lateral margins reflexed at the base, apical margin bent forward and complicate in the middle, forming a very acute compressed ridge, white except for a crimson purple band which runs along the mid-line from the base to the top of the sepal, and green area at the base that is hairy and speckled with red; lateral sepals combined into 1 broadly ovate, acute, greenish white, concave, anterior sepal, with recurved margins placed directly under the lip; petals linear-oblong, with crisped margins, deflexed, curved for ward, greenish spotted with dull red and with a reddish-crimson midline, hairy at the base, labellum bell-shaped with rounded auricles, greenish with an olive-brown glossy anterior part; column short, hairy; staminode orbicular with strongly recurved margins, bright purple margined with white.

Cypripedium villosum Lindl. (*Pollen Parent*).—Leaves strap-shaped, green, bifid at the apex, keeled beneath, with small purple spots at base; youngest leaf not very much shorter than others, erect for about half its length, sheathing around flower-stalk, then spreading. Flower-stalk shorter than the leaves, very hairy, green with long purple hairs; bract large, broadly ovate, compressed, green with purple spots at base extending along midrib inclosing almost the entire ovary. Flowers large and glossy; dorsal sepal deep purple-brown at base, also extending up along main veins, then green with a narrow white margin; anterior sepal yellowish green, with 2 narlow lines of purple extending down the 2 main veins, apiculate; petals unequal, the posterior half being much broader than the anterior, the posterior brown, the lower half more greenish brown, margins undulating; labellum brownish yellow; column short hairy; staminode, greenish brown with prominent apex and greenish tubercle.

Cypripedium lathamianum (*Hybrid*).—Leaves green above, keeled beneath and with purple spots at the base, which are closer together and darker than in *C. villosum;* youngest leaf short and erect, sheathing the base of the flower-stalk. Flower-stalk erect, 1-flowered, hairy; bract, yellow-green with many purple dots, inclosing the ovary to about half of its length. Flowers large; dorsal sepal resembles *C. spicerianum;* white with a broad purple midrib, greenish at the base, striped and speckled with brown above this, lateral halves marked with pink; anterior sepal green with 2 narrow brown-purple veins; petals bent forward, margin very wavy, with deep purple midline which divides it into an olive-brown upper half and a brownish-green lower half; labellum almost as in *C. villosum,* but of a lighter greenish-ochre color; column short, hairy; staminode resembles in shape that of *C. spicerianum,* color a greenish purple with white margin, apex very short and with green tubercle.

Cypripedium lathamianum inversum (*Hybrid*).—Leaves green above, keeled beneath, with purple spots at the base which are closer together than in *C. villosum* but are not as large as in *C. lathamianum,* youngest leaf short, erect, sheathing the base of the flower-stalk. Flower-stalk erect, 1-flowered, hairy; bract short, yellow-green with very small purple dots, inclosing the ovary from about one-third to one-half its length. Flowers large; dorsal sepal very similar to *C. lathamianum* but basal green area is more yellowish and also extends for a greater distance up the sepal; anterior sepal yellowish, purple markings over the veins very faint; petals bend forward, margin very wavy with a deep purple mid-line which divides it into brownish upper half and a yellowish-green lower half, the mid-line being wider in this *hybrid* than in *C. lathamianum,* at the base more yellowish than in *C. lathamianum;* labellum more brownish than in *C. lathamianum;* column short, hairy; staminode, shape between that of *C. lathamianum* and *C. villosum,* purplish green, apex not as prominent as in *C. villosum* but more so than in *C. spicerianum.*

Comparisons of the Macroscopic Characters.

Two different plants of *C. spicerianum* were examined, the first being almost identical with the left-hand figure in Curtis's Botanical Magazine Table 6490. The second differs in the color of the flower-stalk, color and hair of the ovary, color of dorsal sepal, and in the number and size of hairs, otherwise they are alike. These plants are designated No. 1 and No. 2.

Leaf.

The leaves of all four plants are persistent, strap-shaped, bifid at the apex, leathery, keeled beneath, varying shades of green and marked toward the base on the under side with dull purple. They are very much shorter and narrower in *C. spicerianum* than in *C. villosum,* and though the average length and width of the leaves in *both hybrids* are between those of the parents, they are much nearer *C. villosum* than *C. spicerianum.* (Table J 51.)

The leaves of *C. spicerianum* on the under surface near the base have large purple spots or blotches. Those of *C. villosum* have small purple dots. Those of *C. lathamianum* have blotches that are arranged more or less in lines and so close together that the area is almost entirely dull purple, thus resembling *C. spicerianum.* Those of *C. lathamianum inversum* have spots that are smaller and farther apart, becoming nearer *C. villosum.* These markings extend along the lower surface of the leaf for a much greater distance in *C. villosum* than in *C. spicerianum,* and in *both hybrids* while the length of the area is between those of the parents, it is slightly nearer that of *C. villosum* (7 to 7.5 cm.) than *C. spicerianum* (2 to 3 cm.); the length in *C. lathamianum* is 5 to 7 cm., in *C. lathamianum inversum* 5.5 to 7 cm.

In all four plants the youngest leaf is somewhat shortened, embracing the base of the flower-stalk. In *C. spicerianum* it is very much shorter than in *C. villosum.* In both *hybrids,* it is between those of the parents, that

of *C. lathamianum inversum,* however, being much nearer *C. spicerianum,* and that of *C. lathamianum* is much nearer *C. villosum.* The amount of shortening, that is the ratio of the short leaf to the regular length of leaf, is in *C. lathamianum* exactly mid-intermediate (4:4), while in *C. lathamianum inversum* it is identical with that of *C. spicerianum.* (Tables J 50 and J 51.)

TABLE J 50.

	Length.	Ratio.
C. spicerianum	4.4	2 : 5
C. villosum	21.0	4 : 5
C. lathamianum	15	3 : 5
C. lathamianum inversum	8.6	2 : 5

C. spicerianum flowers much earlier than *C. villosum,* those of the former opening in November, and those of the latter in February. The *hybrids* flower at a time between the times of the parents, in January but nearer the flowering period of *C. villosum.*

FLOWER-STALK.

The *flower-stalk* is shorter in *C. spicerianum* than in *C. villosum.* It is between the parents in *both hybrids,* in *C. lathamianum* nearer *C. villosum* and in *C. lathamianum inversum* nearer *C. spicerianum.* (Table J 51.)

The flower-stalk in *C. spicerianum* No. 1 is brownish purple and hairy. (In *C. spicerianum* No. 2 it is deep purple at the base, becoming greenish purple toward the top, and smooth except at the top where it is slightly hairy.) In *C. villosum* it is grassy green with long purple and colorless hairs. In *C. lathamianum* it is green with purple specks, and with shorter hairs than in *C. villosum.* In *C. lathamianum inversum* it is green with shorter purple hairs than in *C. villosum.*

At the top of the flower-stalk is a *bract* which surrounds the base of the ovary. It is linear-oblong and compressed. It is shorter in *C. spicerianum* than in *C. villosum,* and though between the two parents in *both hybrids* it is much nearer *C. spicerianum.* It incloses about half of the ovary in *C. spicerianum;* almost the entire ovary in *C. villosum;* about one-half of the ovary in *C. lathamianum;* and from one-third to one-half of the ovary in *C. lathamianum inversum.* (Table J 51.)

TABLE J 51.

	C. spicerianum.	C. villosum.	C. lathamianum.	C. lathamianum inversum.
Length and width of leaves:	*cm.*	*cm.*	*cm.*	*cm.*
Length	10.3	27.6	25.4	20.7
Width	1.9	3.2	2.8	2.7
Length of youngest leaves inclosing flower-stalk	4.4	21	15	8.6
Length of flower-stalk	13.5	18.3	16.4	14.1
Length of bracts at base of ovary	2.1	5.3	2.6	2.6
Length of ovary of flower	3.9	5.5	4.8	5.2
Length and width of dorsal sepals:				
Length	3.7	6.1	4.4	5.3
Width	4.2	3.5	4.5	4.6

The *bracts* are green or yellowish green with purple spots which are arranged somewhat differently in the four plants.

The *ovary* is 3-sided with 3 ridges. It is shorter in *C. spicerianum* than in *C. villosum.* It is between those of the parents in *both hybrids,* in *C. lathamianum* it being almost mid-intermediate, and in *C. lathamianum inversum* much nearer *C. villosum.* (Table J 51.)

It is brownish purple and hairy in *C. spicerianum* No. 1. (In *C. spicerianum* No. 2 it is purple, but smooth.) In *C. villosum* the color is pale green with a few purple specks, and there are many long purple hairs. In *C. lathamianum* the color is a much darker green than in *C. villosum,* with very many red-purple dots which are close together on the flat faces and there are purple hairs. In *C. lathamianum inversum* the green is lighter than in *C. lathamianum* but darker than in *C. villosum;* purple hairs are present, and also small purple dots in less number than in *C. lathamianum.*

The *dorsal sepal* is shorter and broader in *C. spicerianum* than in *C. villosum.* In *both hybrids* the width is greater than in *either parent,* and the length, though between those of the parents, is in *C. lathamianum* much nearer *C. spicerianum,* and in *C. lathamianum inversum* much nearer *C. villosum.* (Table J 51.)

The ratio of length to width is between those of the parents. In *C. spicerianum* the sepal is shorter than wide; in *C. villosum,* longer than wide; in *C. lathamianum,* shorter than wide, but the difference is not so much as in *C. spicerianum;* and in *C. lathamianum inversum,* longer than wide, though the difference is not so much as in *C. villosum.* In *C. spicerianum* the base of the dorsal sepal is broad and green with reddish hairs. Above this it expands into a broad, pure white, obcordate blade which is folded together along the midrib to form a ridge having a reddish-purple color. The dorsal sepal is strongly bent forward on each side of the apex. (In *C. spicerianum* No. 2 the white area is tinted with pale-pink lavender.) In *C. villosum* the entire base is colored a deep red-brown, running up along the veins to the middle of the sepal, the rest, except for a narrow white margin, is a rather deep shade of green; the margin toward the apex is merely dented in, and does not form a strong undulation as in *C. spicerianum.* In *C. lathamianum* the lateral margins are not recurved as much as in *C. lathamianum inversum,* thus making the sepal appear much broader at the top. The basal greenish area, speckled and striped with brown, does not extend as far up the sepal as in *C. lathamianum inversum,* and it gradually changes to pink. The white margin is slightly deeper than in *C. lathamianum inversum,* and it is also ridged and purple-red along the midrib. As a whole, it appears to resemble *C. spicerianum* more than *C. villosum,* although it gets the brown streaks and dots at the base from *C. villosum* and the greenish area extends up further than in *C. spicerianum.* In *C. lathamianum inversum* the dorsal sepal resembles that of *C. lathamianum* except that the shape is a little nearer that of *C. villosum,* and the greenish basal area contains more yellow and extends further up the sepal.

The 2 *lateral sepals* of the true orchids are joined in the Cypripedieæ to form one anterior sepal placed directly below the labellum. The *anterior sepal* is shorter and slightly wider in *C. spicerianum* than in *C. villosum.*

In *both hybrids* the length is between those of the *parents,* though in *C. lathamianum* it is nearer *C. spicerianum,* while in *C. lathamianum inversum* it is nearer *C. villosum;* the width, however, is identical in both plants with that of *C. spicerianum.* (Table J 52.)

In *C. spicerianum* the anterior sepal is broadly ovate with recurved margins, and pale green with no markings; in *C. villosum,* yellowish green with two narrow lines of brownish purple extending along the 2 median veins; in *C. lathamianum,* a little darker green than in *C. villosum,* with two narrower brown-purple veins; in *C. lathamianum inversum,* it is a much more yellowish green than in *C. villosum,* and the brown-purple lines at the very base of the veins are extremely faint.

The *lateral petals* are linear oblong obtuse, and slightly spatulate in *C. villosum,* smaller in *C. spicerianum* than in *C. villosum,* and between the two parents in *both hybrids.* The length, however, in *both hybrids* is nearer that of *C. villosum,* but the width nearer that of *C. spicerianum.* (Table J 52.)

In *C. spicerianum* the *petals* are practically of the same width for their whole length, but toward the apex they may be slightly narrower than at the base. In *C. villosum* they are very much narrower at the base than across the apical half, in fact the latter is almost three times the width of the base. In *C. lathamianum* they are a little narrower at the base than near the apex, but resemble *C. spicerianum* more than *C. villosum.* In *C. lathamianum inversum* the apical width is greater than the basal width, thus resembling *C. villosum* more than does *C. lathamianum,* but still being nearer *C. spicerianum* than *C. villosum.*

The dorsal margin in *C. spicerianum* is crisped, the ventral margin wavy. In *C. villosum* the margins are merely undulating. In *C. lathamianum* the dorsal margin is nearly as crisped as in *C. spicerianum,* and considerably more than in *C. villosum.* In *C. lathamianum inversum,* the dorsal margin is also crisped, but not quite as much as in *C. lathamianum,* appearing to be between *C. lathamianum* and *C. villosum.* This character in *both hybrids* is nearer *C. spicerianum* than *C. villosum.*

The *color of the petals* in *C. spicerianum* is green, speckled with red-brown, with a midline of red-purple, and the petal is hairy at the base. In *C. villosum* the petal is distinctly divided into halves by the mid-line of reddish purple-brown. The upper half is of a darker brown, the lower half more greenish, also hairy at the base. In *C. lathamianum* the petal is also divided into an upper and lower half by a reddish purple-brown midrib. Upper part is of an olive-brown, deeper than in *C. villosum;* the lower half more greenish (with a trace of brown) than in *C. villosum,* and hairy at the base. In *C. lathamianum inversum* the deep-purple mid-vein (though not so deep in color as in *C. villosum* but wider than in *C. lathamianum*) also divides the petal into halves, the upper half being brownish, the lower half yellowish green, more yellowish than in *C. villosum* or *C. lathamianum.*

The *labellum* is sac-bell-shaped, and smaller in *C. spicerianum* than in *C. villosum.* In length it is in *both hybrids* between the *parents,* though in *C. lathamianum* it is nearer *C. spicerianum,* and in *C. lathamianum inversum* nearer *C. villosum.* The width, measured across the widest part, is greater in *both hybrids* than in *either parent.* (Table J 52.)

The *color of the outer surface of the labellum* in *C. spicerianum* is green at the base and olive-brown toward the anterior rounded end. In *C. villosum* it is yellowish green at the base, becoming brownish yellow toward the anterior. In *C. lathamianum* it is more greenish at the base than in *C. villosum,* becoming olive-green toward the anterior, with brown veins, but not as brown as in *C. villosum.* In *C. lathamianum inversum* it is more yellowish at the base than in *C. villosum,* rather a greenish orange-brown toward the anterior; more yellowish than in *C. lathamianum,* but not as brown as in *C. villosum.*

The *color of the inside of the labellum* in *C. spicerianum* at the base is greenish, with purple hairs and brownish-purple specks which become more numerous toward the anterior until the whole anterior surface is a solid brownish purple. In *C. villosum* at the base it is pale yellow, with purple hairs and red-purple dots over the veins, becoming greenish toward the anterior, with a faint suggestion of brownish violet. In *C. lathamianum* it is greenish yellow at the base, with purple hairs and red specks over the veins which become smaller toward the anterior which is of a dark greenish purple. In *C. lathamianum inversum* it is deeper yellow at the base than in *C. villosum,* with purple hairs and specks, becoming greenish yellow with larger purple specks toward the anterior where it is orange-green, with reddish-brown spots and veins.

TABLE J 52.

.	C. spicerianum.	C. villosum.	C. lathamianum.	C. lathamianum inversum.
Length and width of anterior sepal:	*cm.*	*cm.*	*cm.*	*cm.*
Length	3.2	5.8	4	4.7
Width	2.7	2.5	2.7	2.7
Length and width of lateral petals:				
Length	4.1	6.8	5.7	6.2
Width	1.8	3	2	2.3
Length and width of labellum:				
Length	4.2	6	5	5.5
Width	2.2	3	3.1	3.4
Width of staminode	0.8	1.4	1.2	1.4

At the top of the short hairy column is the flat shield-shaped *staminode.* This is very small and has a rather wavy margin in *C. spicerianum,* and has no pointed apex. At the posterior the margin bends in on each side to form two infoldings that almost meet. In *C. villosum* the staminode is larger, the margin is not wavy, the apex is pointed, and there are no indentations at the posterior. In *C. lathamianum* the shape of the staminode is about mid-intermediate between those of *C. spicerianum* and *C. villosum;* a pointed apex is present, but it is not as acute as in *C. villosum;* and the posterior infoldings of the margin appear to extend exactly one-half the distance toward the interior, as they do in *C. spicerianum.* In *C. lathamianum inversum* the staminode is in shape nearer that of *C. villosum* than of *C. spicerianum;* a pointed apex identical with that of *C. lathamianum* is present; and the posterior indentations extend in only about one-fourth of the distance in *C. spicerianum.* The

staminode of *C. spicerianum* is narrower than that of *C. villosum;* that of *C. lathamianum* is between those of the *parents* but is nearer *C. villosum;* that of *C. lathamianum inversum* is of exactly the same width as in *C. villosum.* (Table J 52.)

The *color of the staminode* of *C. spicerianum* is purple with a white margin and a yellow tubercle. In *C. villosum* it is olive-green, with short purple hairs and a greenish tubercle. In *C. lathamianum* it is a greenish purple with a white margin, with long purple hairs and a green tubercle. In *C. lathamianum inversum* it is purplish green, much more green than in *C. lathamianum,* with long purple hairs and a small greenish tubercle.

Comparisons of the Microscopic Characters.

Leaf.

Sections of the *upper epidermis* of leaves of the same age (second youngest) from the four plants were made at the apex, middle, and base. At the *apex* the cells are hexagonal, with a thick cuticle. The cell-walls are not nearly as thick in *C. spicerianum* as in *C. villosum;* very slightly thicker in *C. lathamianum* than in *C. spicerianum;* and slightly thicker in *C. lathamianum inversum* than in *C. lathamianum. C. lathamianum inversum* is therefore nearer *C. villosum,* and *C. lathamianum* nearer *C. spicerianum.* The difference between the *two hybrids* is very slight.

The *cells* are much larger in *C. spicerianum* than in *C. villosum,* and in *both hybrids* they are between those of the *parent cells,* but nearer *C. spicerianum* in length and nearer *C. villosum* in width. Comparing the cells of the *two hybrids,* those of *C. lathamianum inversum* are larger than those of *C. lathamianum,* thus resembling those of *C. spicerianum* more than those of the other hybrid. (Table J 53.)

At the *middle* of the leaf the *cell-walls* are practically identical in thickness in all four plants. The *cells* are larger in *C. spicerianum* than in *C. villosum;* those of *C. lathamianum* are between those of the *parents* though in width much nearer *C. spicerianum* and in length nearer *C. villosum.* The cells of *C. lathamianum inversum* are larger than in *either parent.* (Table J 53.)

At the *base* of the leaf, the *upper epidermal cells* are smaller in *C. spicerianum* than in *C. villosum.* In *C. lathamianum* they are larger than in *either parent,* and the width of *C. lathamianum inversum* is greater than in *either parent.* The length, however, is between those of the *parents,* though much nearer *C. villosum* than *C. spicerianum.* (Table J 53.)

The average size of the *upper epidermal cells* of the *whole leaf* is greater in *C. spicerianum* than in *C. villosum.* The *cells* of the *hybrids* are wider than in *either parent,* and though between the two parents in length are much nearer *C. spicerianum* than *C. villosum.* Those of *C. lathamianum* are longer and narrower than those of *C. lathamianum inversum.* (Table J 53.)

Sections of the *lower epidermis* were also examined at the apex, middle, and base of the leaf. The lower epidermal cells at the *apex* are hexagonal or elongated-hexagonal, with somewhat thick walls and a thick cuticle. They are shorter and broader in *C. spicerianum* than in *C. villosum.* In *both hybrids* the width is between those of the parents, though nearer *C. spicerianum;* the length in *C. lathamianum* is between those of the parents, but nearer *C. villosum;* and in *C. lathamianum inversum* the length is greater than in *either parent.* (Table J 53.)

Stomata are present on the lower epidermis. At the *apex* they number 8.3 in *C. spicerianum,* 9.2 in *C. villosum,* 8.8 in *C. lathamianum,* and 7.4 in *C. lathamianum inversum.*

At the *middle* of the leaf, the *lower epidermal cells* in *C. spicerianum* are shorter than in *C. villosum* but of almost the same width. In *C. lathamianum* the length is between those of the parents, but nearer that of *C. villosum;* in *C. lathamianum inversum* the length is identical with that of *C. villosum.* In *both hybrids* the cells are wider than in *either parent.* (Table J 53.)

Stomata at the *midrib* of the leaf are 8.2 in *C. spicerianum,* 7.7 in *C. villosum,* but less numerous in *both hybrids* than in *either parent,* although the number in *C. lathamianum* (7.6) is almost identical with that of *C. villosum* (6.4).

The *lower epidermal cells* at the *base* of the leaf are elongated hexagonal, with thick walls and a thick cuticle. They are smaller in *C. spicerianum* than in *C. villosum.* In *C. lathamianum* the length is greater than in *either parent,* being only slightly longer than in *C. villosum.* In *C. lathamianum inversum* the length, while between those of the *parents,* is much nearer *C. spicerianum.* The width in *both hybrids* is greater than in *either parent.* (Table J 53.)

Stomata are very rare at the *base* of the leaf, there being 2.4 in *C. spicerianum,* none in *C. villosum,* 1.4 in *C. lathamianum,* and 0.5 in *C. lathamianum inversum.*

The average size of the lower epidermal cells for the *whole leaf* is less in *C. spicerianum* than in *C. villosum.* In *both hybrids* the length is between those of the *parents,* though nearer *C. villosum* than *C. spicerianum;* the width, however, is greater than in *either parent.* (Table J 53.)

The *lower surface* of the leaf at the *base* has large, dull, purple blotches in *C. spicerianum* that are due to many cells grouped together and filled with a red-violet sap. *C. villosum* has small, dull, brownish-purple dots due to groups of 5 or 6 cells being filled with a red-purple sap. *C. lathamianum* has many dull-purple blotches that are arranged in lines, and so close together that the base is almost entirely dull purple. This is due to a deep red-violet sap in groups of several cells. The smaller purple spots in *C. lathamianum inversum* are also due to the same cause.

Transverse sections of the leaves of the same age were made *midway between the apex and the base* (Plate 34, figs. 202, 203, 204, and 205) and examined at the midrib region. The *upper epidermal cells* are supplied with a thick cuticle, and with a layer of wax above it. The *cuticle* is much thicker in *C. spicerianum* than in *C. villosum,* but not as thick in the *two hybrids* as in *either parent.* The cells are greatly elongated in depth, forming an aqueous tissue. They are much deeper in *C. spicerianum* than in *C. villosum;* between the *parents* in *C. lathamianum inversum* though nearer *C. villosum;* and shorter than in *either parent* in *C. lathamianum.* (Table J 53.)

The *lower epidermal cells* directly beneath the *midrib bundle* were compared as to the thickness of the outer wall and the size of the cells. The outer wall is

not as thick in *C. spicerianum* as in *C. villosum*, and less thick in *both hybrids* than in *either parent*. The cells are less deep but wider in *C. spicerianum* than in

TABLE J 53.

	C. spicerianum.	C. villosum.	C. lathamianum.	C. lathamianum inversum.
Length and width of cells of upper epidermis at apex of leaf:	μ	μ	μ	μ
Length	138.6	105.5	123.8	124.9
Width	117	84.6	93.2	100.1
Length and width of cells of upper epidermis at middle of leaf:				
Length	155.1	144.3	147.6	158.4
Width	131.7	109.1	129.6	134.6
Length and width of cells of upper epidermis at base of leaf:				
Length	114.1	150.1	157.2	141.5
Width	61.9	85.3	106.5	98.3
Size of cells of upper epidermis for whole leaf:				
Length	144.9	133.3	142.9	141.6
Width	103.5	93	109.8	111
Length and width of cells of lower epidermis of apex of leaf:				
Length	70.5	77.7	75.6	80.3
Width	56.1	50.7	55.1	54.7
Length and width of cells of lower epidermis at middle of leaf:				
Length	84.2	87.1	86	87.1
Width	57.2	57.6	61.9	61.2
Length and width of cells of lower epidermis at base of leaf:				
Length	99.3	110.1	111.6	100.8
Width	54.7	65.1	66.2	67.3
Length and width of cells of lower epidermis for entire leaf:				
Length	84.7	91.6	91.1	89.4
Width	56	57.8	61.1	61.1
Depth of cuticle, wax, and cells of upper epidermis on a transverse section midway between apex and base at midrib:				
Depth of cuticle and wax	34.2	27	22.3	24.1
Depth of upper epidermal cells	864	363.6	229.7	501.1
Depths of outer walls and depth and width of cells of lower epidermis on a transverse section midway between apex and base at midrib:				
Depth of outer wall	25.2	28.8	16.9	21.6
Depth of lower epidermal cells	28.8	29.9	30.9	38.1
Width of lower epidermal cells	47.5	36.7	41.4	48.2
Depth and width of midrib bundle on transverse section:				
Depth	178.5	369	362.5	270
Width	147.6	236.9	259.2	201.6
Thickness of transverse section at midrib	1628.6	1738.2	1900.1	1934.9

C. villosum. In *both hybrids* they are deeper than in *either parent*, and in *C. lathamianum inversum* they are wider than in *either parent*. In *C. lathamianum*, however, they are between those of the *parents* in width, but slightly nearer *C. villosum*. (Table J 53.)

Between the elongated upper epidermal cells and the lower epidermal cells are many layers of small, rounded, chlorophyll-containing cells, embedded in which is the *midrib bundle* that consists of a patch of thin-walled cells, the *phloem* below, and thick-walled cells, the *xylem* above, and all surrounded by a fibrous sheath. The midrib bundle is much smaller in *C. spicerianum* than in *C. villosum*. In *both hybrids* the depth of the bundle is between those of the *parents*, that of *C. lathamianum inversum* being almost exactly mid-intermediate between those of the *parents;* and that of *C. lathamianum* being very near *C. villosum*. The width in *C. lathamanium inversum* is between those of the *parents*, though nearer *C. villosum;* and that of *C. lathamianum* is greater than in *either parent*.

The thickness of the transverse sections at the midrib of the four plants was also measured. *C. spicerianum* was found to be not as thick as *C. villosum*, but the *two hybrids* have a greater thickness than in *either parent*.

FLOWER-STALK.

Sections of the *epidermis* of the *flower-stalk* were examined just below the ovary and also at a point midway between the ovary and base of the flower-stalk. At the former position the epidermal cells are somewhat rectangular, with thin lateral walls and a thick cuticle. They are smaller in *C. spicerianum* than in *C. villosum*. In *both hybrids* the length is between those of the *parents*, though in *C. lathamianum* it is much nearer *C. villosum*, and in *C. lathamianum inversum* nearer *C. spicerianum*. The width in the *hybrids* is greater than in *either parent*. (Table J 54.)

Hairs are present at the top of the flower-stalk. They are long and pointed in *C. spicerianum;* equal numbers of club-shaped and pointed hairs in *C. villosum;* all pointed in *C. lathamianum;* and only 1 in 25 club-shaped in *C. lathamianum inversum*. In this character *both hybrids* seem to resemble *C. spicerianum* more than *C. villosum*. There are 2 hairs in a field in *C. spicerianum* No. 1 and 6 in 10 in No. 2; 2.7 in *C. villosum;* and 2.1 in *C. lathamianum inversum*. The pointed hairs are shorter in *C. spicerianum* than in *C. villosum*, and in length in the *hybrid* are between those of the *parents*, though much nearer *C. spicerianum* than *C. villosum*. The club-shaped hairs are present only in *C. villosum* and *C. lathamianum inversum*, and are very nearly as long in the latter as in *C. villosum*. (Table J 54.)

The *top* of the *flower-stalk* in *C. spicerianum* is hairy, and brownish purple due to all of the epidermal cells, except those from which the hairs arise, being filled with deep-violet cell sap. The hairs contain orange chromoplasts. (In *C. spicerianum* No. 2 the flower-stalk is greenish purple at the top, and only slightly hairy. The color is due to a few cells and a few of the basal cells of the hairs containing violet sap, the others containing pale-green plastids.) In *C. villosum* the color is green, with many purple and colorless hairs, due to cells containing green plastids, others with violet sap and yellow chromoplasts. All of the hairs contain yellow chromo-

plasts which become orange-brown in the end-cells. Nearly all the hairs contain deep-violet sap. In *C. lathamianum* the color is green with shorter hairs and purple specks, due to some cells containing yellowish-green plastids, others, 2 or 3 together, with violet sap and yellow chromoplasts, these being in much greater number than in *C. villosum;* hairs have yellowish-green plastids and a violet sap. In *C. lathamianum inversum* the color is a lighter green, with short purplish hairs, the color being due to the same causes as in *C. lathamianum,* but there are fewer cells with violet sap grouped together.

The *epidermis* at the *middle* of the flower-stalk consists of thin-walled, rectangular cells with a thick outer cuticle. They are smaller in *C. spicerianum* than in *C. villosum,* and in width are between those of the *parents* in *both hybrids,* though nearer *C. villosum.* In length, that of *C. lathamianum* is greater and that of *C. lathamianum inversum* less than in *either parent.* (Table J 54.)

TABLE J 54.

	C. spicerianum.	C. villosum.	C. lathamianum.	C. lathamianum inversum.
Length and width of cells of epidermis of flower-stalk at top:	μ	μ	μ	μ
Length	95	123.8	120.9	101.9
Width	42.8	52.9	58.3	60.5
Hairs at top of flower stalk:				
Length of pointed hairs, No. 1	457.6	1534.7	532.4	591.6
Length of pointed hairs, No. 2	271.4	......	.....	.....
Length of club-shaped hairs	0	407.1	0	382.8
Length and width of cells of epidermis of flower-stalk at middle:				
Length	139.3	143.6	154.4	117
Width	37.4	55.8	49.3	50
Hairs of flower-stalk at middle:				
Length of pointed hairs, No. 1	354.9	1216.2	683.8	683.8
Length of pointed hairs, No. 2	288.8	......	.....	.....
Length of club-shaped hairs	0	450.6	443.7	424.5
Thickness of outer wall, depth, and width of cells of flower-stalk at middle:				
Thickness of outer wall	14.4 to 18	9 to 10.8	16.2 to 18	19.8 to 25.2
Depth	59.7	67.7	53.3	66.9
Width	33.8	47.9	41	42.1
Width of cortex in a transverse section of flower-stalk	252	540	396	306

Hairs similar to the foregoing are present at the *middle* of the flower-stalk. Pointed hairs only are present in *C. spicerianum;* twice as many pointed as club-shaped hairs in *C. villosum;* many pointed and very few club-shaped hairs in *C. lathamianum;* and pointed with many club-shaped hairs (more than in *C. villosum*) in *C. lathamianum inversum.* In the number of club-shaped hairs *C. lathamianum* is very nearly mid-intermediate between those of the parents, but the number in *C. lathamianum inversum* goes beyond that of *either parent.*

Hairs number 2.3 in *C. spicerianum,* 3.1 in *C. villosum,* 2.9 in *C. lathamianum,* and 3.7 in *C. lathamianum inversum.* In *C. spicerianum* No. 2 hairs are very much less numerous and shorter than in *C. spicerianum* No. 1. The pointed hairs are shorter in *C. spicerianum* than in *C. villosum,* and in length in the *hybrids* between the *parents,* but nearer *C. spicerianum* than *C. villosum.* The club-shaped hairs are only slightly shorter in *both hybrids* than in *C. villosum.*

The *color* is the same at the *middle* as at the top of the flower-stalk, except in *C. spicerianum* No. 2 where it is a dark purple, due to most of the cells being filled with violet sap and yellow chromoplasts. Other cells contain only yellow chromoplasts, and a very few colorless hairs are present.

Transverse sections of the flower-stalk were taken at a point *midway between the top and the base.* Outermost is a layer of epidermis that consists of rounded cells with slightly thickened inner and lateral walls and a greatly thickened outer wall. The outer wall is ridged in all of the plants, and it is thicker in *C. spicerianum* than in *C. villosum,* and thicker in *both hybrids* than in *either parent.* From this layer arise the hairs. The epidermal cells themselves are smaller in *C. spicerianum* than in *C. villosum,* and are in *both hybrids* between the parents in size, except for the depth in *C. lathamianum* which is less than in *either parent.* The depth in *C. lathamianum inversum* is nearer that of *C. villosum.* The width in *C. lathamianum* is almost exactly mid-intermediate between the widths of the *parents;* in *C. lathamianum inversum,* however, it is nearer that of *C. villosum.* (Table J 54.)

Beneath the *epidermis* are several layers of thin-walled, rounded cells containing green chloroplasts, the *cortex,* with the walls of the outermost layer slightly thickened. This zone is 6 to 8 rows deep in *C. spicerianum,* 10 to 12 in *C. villosum,* 8 to 10 in *C. lathamianum,* and 6 to 7 in *C. lathamianum inversum,* thus being almost exactly mid-intermediate in *C. lathamianum* and the same or less than in *either parent* in *C. lathamianum inversum.* The *cortex* is not as wide in *C. spicerianum* as in *C. villosum,* and it is between the *parents* in *both hybrids,* being exactly mid-intermediate in *C. lathamianum* and nearer *C. spicerianum* in *C. lathamianum inversum.* (Table J 54.)

Within the cortex is the vascular cylinder, composed outermost of several thickened layers of cells, and within of rounded thin-walled cells in which are embedded the bundles.

FLOWER.

Sections of the *upper epidermis of the dorsal sepal* of the four plants were taken at the *middle point along the midrib.* The cells are wavy-walled, slightly shorter but wider in *C. spicerianum* than in *C. villosum,* but larger in *both hybrids* than in *either parent.* (Table J 55.)

Multicellular hairs are present on the *upper epidermis* in *C. spicerianum* and the *two hybrids,* but absent in *C. villosum.* (Table J 55.) They consist of from 3 to 5 cells linearly arranged, the lower cells being more elongated, the upper more compressed and slightly swollen, giving the hair a club-like appearance, the end cell being rounded and containing a great many chromoplasts. They

are more numerous and longer in the *both hybrids* than in *C. spicerianum*—0.5 in *C. spicerianum*, none in *C. villosum*, 1.3 in *C. lathamianum*, 0.76 in *C. lathamianum inversum.*

The *color* at the midrib is red-purple in *C. spicerianum, C. lathamianum*, and *C. lathamianum inversam*, and pea-green with dark-brown veins in *C. villosum.* The color is due in *C. spicerianum* to the cells being filled with a deep reddish-violet cell sap; in *C. villosum* the cells of the upper epidermis containing green plastids, and those of the layer beneath containing a red-violet cell sap; in *C. lathamianum* and *C. lathamianum inversum* to a deep red-violet sap in most of the cells of the layer beneath and also probably in the upper epidermis, other epidermal cells contain pale yellowish-green plastids and others both the yellowish-green plastids and the red-violet cell sap.

Sections of the *lower epidermis at the middle of the midrib* were also examined. The cells are much elongated, and hairs are very numerous. There are two types of hairs: one, the pointed, consisting of 2 to 4 cells in a line, the end cell being pointed; the other, club-shaped, like the other except that the 2 or 3 end-cells are shortened and the last one swollen. The pointed hairs are present in *C. spicerianum*, and club-shaped hairs are very rare. The pointed hairs are less numerous than the club-shaped in *C. villosum;* they are 1 to 4 in *C. villosum*, 3 to 2 in *C. lathamianum*, and 2 to 1 in *C. lathamianum inversum*, but more numerous in the *hybrids.* The pointed hairs are shorter in *C. spicerianum* than in *C. villosum*, and in the *hybrids* they are between those of the *parents*, though in *C. lathamianum* much nearer *C. spicerianum*, and in *C. lathamianum inversum* much nearer *C. villosum.* The club-shaped hairs are also shorter in *C. spicerianum* than in *C. villosum.* Those of *C. lathamianum*, though between those of the *parents*, are nearer *C. spicerianum*, and those of *C. lathamianum inversum* are shorter than in *either parent.* (Table J 55.)

The *color* is red-purple in *C. spicerianum* and *C. lathamianum*, greenish purple in *C. lathamianum inversum*, and green with long numerous purple hairs in *C. villosum.* It is due in *C. spicerianum* to all of the epidermal cells, except those from which hairs arise, being filled with a deep red-violet sap, and the hairs while not containing a red-violet cell sap have yellow-orange chromoplasts; in *C. villosum* to the epidermal cells being filled with yellowish-green plastids and the hairs being filled with a violet cell sap and yellowish-green plastids, the end-cells of the club-shaped hairs being packed with yellow-brown chromoplasts; in *C. lathamianum* to some cells that are filled with yellowish-green plastids and others with plastids and violet cell sap. The hairs are filled either with only a deep-violet cell sap, or with a violet cell sap and the rounded end-cell with yellow chromoplasts. In *C. lathamianum inversum* there are more cells with yellowish-green plastids and fewer with a violet sap and plastids than in *C. lathamianum.* A few hairs contain violet sap only; others with a violet sap and yellow-brown chromoplasts in blunt end-cells; and others with only a few yellow chromoplasts.

Sections of the *upper epidermis of the dorsal sepal at the base* were also examined. The upper epidermal cells are smaller in *C. spicerianum* than in *C. villosum.* In *both hybrids* the cells are of greater length than in *either parent*, but the width is between those of the *parents*, that of *C. lathamianum* being nearer that of *C. villosum*, that of *C. lathamianum inversum* nearer *C. spicerianum.* (Table J 55.)

Club-shaped hairs are present in *C. spicerianum*, absent in *C. villosum* and present in less numbers in *both hybirds.* They are longer in *both hybrids* than in *C. spicerianum.* (Table J 55.)

The *color* is green with reddish hairs in *C. spicerianum;* deep reddish brown in *C. villosum;* green spotted with deep red-brown in *C. lathamianum;* and a paler green spotted with red-brown in *C. lathamianum inversum.* It is due in *C. spicerianum* to the upper epidermal cells being filled with yellow-green plastids, hairs filled with violet sap, the 2 or 3 end-cells containing yellow chromoplasts; in *C. villosum* to the upper epidermal cells containing greenish-yellow chromoplasts, and to many cells of the layer beneath being filled with a red-violet cell sap; in *C. lathamianum* to the upper epidermal cells containing yellowish-green plastids, in scattered regions to several adjoining cells of the layer beneath containing a red-violet sap, and to hairs containing a violet sap which have end-cells packed with orange chromoplasts; in *C. lathamianum inversum* to the same conditions as in *C. lathamianum*, the only differences being that the chromoplasts in the upper epidermal cells are more yellowish and the hairs more numerous than in *C. lathamianum*, giving an appearance very much like that of the other hybrid.

The *lower epidermis of the dorsal sepal at the base* consists of longer and narrower cells in *C. spicerianum* than in *C. villosum.* The cells of *both hybrids* are larger in both dimensions than in *either parent.* (Table J 55.)

Both *pointed and club-shaped* hairs are present. The former are more numerous than the latter, which are rare, in *C. spicerianum*, while there is the reverse in *C. villosum.* Pointed hairs are 4 to 1 in *C. lathamianum*, and in equal numbers in *C. lathamianum inversum.* The pointed hairs are shorter in *C. spicerianum* than in *C. villosum*, and though the average length in *both hybrids* is between those of the *parents*, it is much nearer *C. spicerianum.* Those of *C. lathamianum inversum* are much longer than those of *C. lathamianum.* The club-shaped hairs also are shorter in *C. spicerianum* than in *C. villosum.* In *C. lathamianum* the average length is shorter than in *either parent.* In *C. lathamianum inversum* the average length, though between that of the *parents*, is much nearer *C. spicerianum.* The club-shaped hairs also are longer in *C. lathamianum inversum* than in *C. lathamianum.* (Table J 55.)

The *color* is green in *C. spicerianum*, green with many long violet hairs in *C. villosum*, green with short violet hairs in *C. lathamianum*, and a slightly paler green with short violet hairs in *C. lathamianum inversum.* It is due in *C. spicerianum* to the lower epidermal cells being filled with yellowish-green plastids, and to hairs that contain yellowish chromoplasts and a few basal cells that contain a violet cell sap; in *C. villosum* to the epidermal cells containing yellowish-green plastids, the hairs all being filled with a violet cell sap, and also with a few yellowish chromoplasts; in both *C. lathamianum* and *C. lathamianum inversum* to the epidermal cells being filled with yellowish-green plastids. A violet cell sap

and a few yellow chromoplasts may be present in both the pointed and the club-shaped hairs. Some of the pointed hairs contain only yellowish chromoplasts, and some of the club-shaped hairs have yellow orange plastids massed in the end-cell. Those containing violet sap are not as numerous in *C. lathamianum inversum* as in *C. lathamianum.*

Sections of the *upper epidermis of the lateral petals* along the *mid-line* and at a point equidistant from the base and the apex were examined. The upper epidermal cells have thin, wavy walls, and are a little shorter and wider in *C. spicerianum* than in *C. villosum.* In *both hybrids* the average length is greater than in *either parent.* The width in *C. lathamianum* is greater than in *either parent;* that of *C. lathamianum inversum* is between those of the parent, but much nearer that of *C. spicerianum.* (Table J 55.)

The *color* is dark green with red-purple midrib in *C. spicerianum,* and is due to cells filled with greenish-yellow plastids, and at the red-purple line to a deep red-violet sap that fills the cells of the layer beneath. In *C. villosum* the color above the midrib is deep red-brown, due to yellow chromoplasts in the upper epidermal cells and a red-violet sap in the layer beneath. The red-brown midrib in *C. lathamianum* and *C. lathamianum inversum* is also due to greenish-yellow chromoplasts in the upper epidermal layer and to a red-violet sap in the cells of the layer beneath. The only difference between the coloring of the *hybrids* is that the red-purple midrib line is broader in *C. lathamianum inversum* than in *C. lathamianum.*

The *lower epidermis of the petals* along the *mid-line* and at a point equidistant from the base and the apex consists of thin-walled, almost hexagonal cells with only very slightly wavy walls in *C. spicerianum;* of cells of more irregular shape and with wavy walls in *C. villosum;* and of cells with irregular wavy walls which appear very much like those of *C. villosum* in the *hybrids.* The cells are shorter and broader in *C. spicerianum* than in *C. villosum,* and are longer and broader than in *either parent.* (Table J 55.)

A few *hairs* are present on the lower epidermis along the midrib. Sections of the *upper epidermis of the petal* at the *anterior part* at the *base* show long pointed *hairs.* These hairs are shorter in *C. spicerianum* than in *C. villosum* and are longer in *both hybrids* than in *either parent.* (Table J 55.)

The *color* of this portion of the petal is green with reddish-brown specks and violet hairs in *C. spicerianum,* and is due to pale yellowish chromoplasts in both upper epidermal cells and hairs, and to a red-violet cell sap in some cells and some hairs. The color in the hairs partially obscures pale-yellow chromoplasts. Other hairs without the red-violet sap contain deeper yellow-orange chromoplasts. In *C. villosum* the color is greenish-yellow with violet hairs and pale brown-purple specks, and is due to a few pale-yellow chromoplasts in the upper epidermal cells and hairs, and to a red-violet cell sap in the hairs and in a few of the cells in the layer beneath the epidermis. In *C. lathamianum* the color is more greenish than in *C. villosum;* in *C. lathamianum inversum* more yellowish than in *C. villosum,* both with brown-purple specks and violet hairs due to yellow chromoplasts in the upper epidermal layer and in the hairs, these chromoplasts being obscured by the violet sap. Violet sap is also present in several areas of cells of the layer beneath the upper epidermis where the brown-purple specks are present.

Sections of the *upper epidermis of the labellum* were taken at the *base* along the mid-line. The epidermal cells are somewhat irregular in shape and have thin, wavy walls. They are smaller in *C. spicerianum* than in *C. villosum.* The relationship in the *hybrids* to the *parents* is very irregular: In length the cells of *C. lathamianum* are between those of the *parents,* but nearer *C. spicerianum,* while in *C. lathamianum inversum* they are longer than in *either parent.* In width, the cells of *C. lathamianum* exceed the widths of those of *either parent;* but the width in *C. lathamianum inversum* is less than in *either parent.* (Table J 55.)

Long pointed *hairs* are numerous. They are shorter in *C. spicerianum* than in *C. villosum;* shorter in *C. lathamianum* than in *either parent;* and between the parents in *C. lathamianum,* but very near that of *C. villosum.* (Table J 55.)

The *color* of this area in *C. spicerianum* is green with purple specks and hairs. This is due to the presence of yellowish-green chromoplasts in most of the cells, a red-violet sap in a few cells, and a red-violet sap and yellowish chromoplasts in the hairs. In *C. villosum* the color is pale yellow, with purple hairs, and with red-purple dots over the veins. This is due to the upper epidermal cells containing a few yellow chromoplasts, to a deep-violet sap in many cells grouped together, and to the short hairs containing yellow chromoplasts and the hairs containing a red-violet sap and yellow chromoplasts. In *C. lathamianum* the same area is greenish yellow with deeper and larger dots than in *C. villosum,* and with purple hairs. Microscopically, the appearance is very similar to that of *C. villosum* except that the areas of the colored cells are more numerous and the red-violet is of a deeper shade. In *C. lathamianum inversum* the area is of a deeper yellow than in *C. villosum,* also with purple specks and hairs. Microscopically this also is very similar to that of *C. villosum,* but the colored areas are not as numerous, nor is the red-violet sap of so deep a shade.

Sections of the *upper epidermis of the labellum* at the most *anterior* part along the mid-line were examined in the four plants. The upper epidermal cells are very wavy-walled. They are of almost the same length but wider in *C. spicerianum* than in *C. villosum.* In length, the cells of *both hybrids* are greater than in *either parent;* in width, those of *C. lathamianum* are between those of the *parents,* though much nearer to *C. spicerianum;* that of *C. lathamianum inversum,* however, is greater than in *either parent.* (Table J 55.)

Long hairs, having the last two cells a little shortened and the last cell rounded so as to resemble somewhat the club-shaped hair, are numerous on this area. They are longer in *C. spicerianum* than in *C. villosum.* They are shorter in *C. lathamianum* than in *either parent;* they are between the *two parents* in *C. lathamianum,* but much nearer those of *C. spicerianum* than *C. villosum.* (Table J 55.)

The color is brownish purple in *C. spicerianum,* and is due to many cells being filled with a pale or deep red-violet cell sap and yellow chromoplasts, to some cells

TABLE J 55.

	C. spicerianum.	C. villosum.	C. lathamianum.	C. lathamianum inversum.
	μ	μ	μ	μ
Length and width of cells of upper epidermis at middle of dorsal sepal along midrib:				
Length	105.5	106.5	120.2	138.6
Width	65.9	59.7	73.4	72.7
Length on upper epidermis of dorsal sepal at middle point	235.1	0	260.3	284.7
Length of hairs on lower epidermis of dorsal sepal along midrib:				
Length of pointed hairs	333.7	1,430.3	654.2	976.1
Length of club-shaped hairs	374.4	581.1	436.7	323.6
Length and width of cells of upper epidermis at base of dorsal sepal:				
Length	92.1	99.3	111.9	108.7
Width	48.2	67.7	65.5	56.9
Length of hairs on upper epidermis at base of dorsal sepal	455.9	0	817.8	817.8
Length and width of cells of lower epidermis at base of dorsal sepal:				
Length	87.1	79.9	104.4	114.5
Width	53.3	57.6	57.9	60.5
Length of pointed and club-shaped hairs on lower epidermis at base of dorsal sepal:				
Length of pointed hairs	343.1	1,658.2	347	631.4
Length club-shaped	450	1,106.6	428.7	465.8
Length and width of cells of upper epidermis at middle of lateral petal:				
Length	101.5	105.1	112.3	113.7
Width	66.9	54	70.5	63.3
Length and width of cells of lower epidermis at middle of lateral petal:				
Length	99.3	119.1	121.3	124.5
Width	68	64.8	73.8	77
Length of hairs on upper epidermis of petals, anterior part at base	1,115.3	1,578.2	1,729.5	1,706.9
Length and width of cells of upper epidermis at base of labellum along mid-line:				
Length	105.1	112.7	107.6	118.4
Width	64.8	65.5	80.6	55.8
Length of hairs on upper epidermis at base of labellum along mid-line:				
Length	1,017.9	1,278.9	953.5	1,273.7
Length of cells of upper epidermis of labellum at most anterior part along mid-line:				
Length	88.5	88.2	103.3	110.5
Width	57.9	50	56.1	59
Length of hairs on upper epidermis of labellum at most anterior part along mid-line	779.5	612.5	602	748.2
Length and width of cells of lower epidermis of labellum between apex and most anterior part:				
Length	111.6	122.6	126.7	132.1
Width	63.3	74.1	74.1	77.7
Length and width of cells of lower epidermis at base of labellum along mid-line:				
Length	114.8	99	121.7	137.1
Width	69.1	65.5	73.1	62.6

which contain only orange-brown chromoplasts, and to hairs which in some instances are filled with a lavender cell sap, and in others have deep orange-brown chromoplasts. In *C. villosum* it is pale brownish-greenish-violet, due to many cells being filled with lavender sap and yellow chromoplasts and a few having yellow chromoplasts only, and to many hairs that contain a pale-violet sap with yellow chromoplasts, and a few that have only orange or brown chromoplasts. In *C. lathamianum* the color is dark greenish-purple, due to the cells being filled with a deeper lavender cell sap than in *C. villosum* together with yellow chromoplasts, and hairs filled with yellow chromoplasts only, and also those with yellow chromoplasts and a violet sap. In *C. lathamianum inversum* the background is orange with reddish-brown spots and veins, due to a deeper violet sap than in *C. lathamianum,* together with yellow chromoplasts in nearly all the cells and to hairs which contain yellow or brown chromoplasts.

Sections of the *lower epidermis of the labellum* were taken at a point between the apex and the most anterior part (between the top of the slipper and the toe). The cells are large and have very wavy walls. They are smaller in *C. spicerianum* than in *C. villosum,* and larger in *both hybrids* than in *either parent,* except in *C. lathamianum* in which the width is identical with that of *C. villosum.* (Table J 55.)

The *color* of this region in *C. spicerianum* is greenish brown, due to yellow chromoplasts and a lavender cell sap in the cells. In *C. villosum* it is brownish green with brownish-violet veins, due to cells which may contain yellow chromoplasts only, and to others which have both yellow chromoplasts and a pale-lavender sap. In *C. lathamianum* it is more like an olive-green with faintly brownish veins, due to the lavender cell sap being less prominent and the yellow chromoplasts more prominent. In *C. lathamianum inversum* it is more of a greenish orange, the yellow being more prominent than in *C. lathamianum.* Under the microscope there appears to be no violet sap, the color being due solely to deep-yellow chromoplasts.

Sections of the *lower epidermis of the labellum* were also taken at the very base along the median line. The

cells are large and have thin very wavy walls. They are larger in *C. spicerianum* than in *C. villosum.* In length they are larger in *both hybrids* than in *either parent;* but in width those of *C. lathamianum* are larger than those of *either parent,* while those of *C. lathamianum inversum* are smaller than in *either parent.*

The *color* of this area is green in *C. spicerianum,* due to yellow chromoplasts in the cells; greenish yellow in *C. villosum,* due to a few pale-yellow chromoplasts, more greenish in *C. lathamianum* than in *C. villosum,* due to yellow chromoplasts; and more orange in *C. lathamianum inversum* than in *C. villosum,* due to much deeper yellow chromoplasts in the cells.

Comparative Summary of the Characters of the Hybrid Cypripedium lathamianum and its Parent-stocks.

The hybrid was found to be:

(1) *The same or practically the same as the seed parent:* In the width of the anterior sepal; kind of hairs present on the epidermis at the top of the flower-stalks.

(2) *The same or practically the same as the pollen parent:* In the number of stomata on the lower epidermis of the leaf at the middle; the shape of the cells, and the waviness of the walls of the lower epidermal cells of the petals at the middle; width of the lower epidermal cells of the labellum between the apex and the most anterior part.

(3) *The same or practically the same as both parents:* In the shape of the leaves, thickness of the leaves; thickness of the cell walls on the upper epidermis of the leaf at the middle; color of the cell sap on the lower epidermis at the base of the dorsal sepal.

(4) *Intermediate:* In the length of leaves ♂ ; width of leaves ♂ ; size of blotches at base of leaf ♀ ; length of spotted area at base of the leaf ♂ ; amount of shortening of the youngest leaf; length of the youngest leaf ♂ ; flowering period ♂ ; length of flower-stalk ♂ ; color of flower-stalk; length of bract ♀ ; length of ovary; color of ovary; length of dorsal sepal ♀ ; ratio of length to width of dorsal sepal; shape of dorsal sepal ♀ ; color of dorsal sepal ♀ ; length of anterior sepal ♀ ; color of anterior sepal ♂ ; length of lateral petals ♂ ; width of lateral petals ♀ ; shape of lateral petals ♀ ; crisping of dorsal margin of lateral petals ♀ ; color of petals; length of the labellum ♀ ; color of outer surface of labellum; color of inner surface of labellum; shape of staminode; width of staminode ♂ ; color of staminode; thickness of cell walls on the upper epidermis of the leaf at the apex ♀ ; length ♀, width ♂, of the upper epidermal cells of the leaf at the apex; length ♂, and width ♀, of the upper epidermal cells of the leaf at the middle; length ♂, and width ♀, of the lower epidermal cells of the leaf at the apex; number of stomata on the lower epidermis of the leaf at the apex; length of the lower epidermal cells of the leaf at the middle ♂ ; number of stomata on the lower epidermis of the leaf at the base; width of the lower epidermal cells ♂, depth of the midrib bundle ♂, on the transverse section of the leaf at the midrib; length of the epidermal cells at the top of the flower-stalk ♂ ; number of hairs ♂, length of the pointed hairs ♀, and color at the top of the flower-stalk; the width ♂ of the epidermal cells at the middle of the flower-stalk; the kind of hairs present, number of hairs ♂, length of the pointed hairs ♀, length of the club-shaped hairs ♂, color at the middle of the flower-stalk; the width of the epidermal cells, number of cortex layers and the width of the cortex on the transverse section of the flower-stalk at the middle; the color of the upper epidermis of the dorsal sepal at the midrib; the ratio of pointed to club-shaped hairs, length of the pointed hairs ♀ ; length of the club-shaped hairs ♀, and the color of the lower epidermis of the dorsal sepal at the midrib; the width of the upper epidermal cells ♂, number of hairs ♂, and the color of the upper epidermis at the base of the dorsal sepal; the ratio of the pointed to club-shaped hairs ♀, length of the pointed hairs ♀, and the color of the hairs on the lower epidermis of the dorsal sepal at the base; the color of the upper epidermis of the petal at the middle; color of the upper epidermis of the petal at the base; length of the upper epidermal cells of the labellum near the base; width of the upper epidermal cells of the labellum at the most anterior part ♀ ; color of the upper epidermis of the labellum at the most anterior part; color of the lower epidermis of the labellum between the apex and the most anterior part; the color of the lower epidermis of the labellum at the base ♀.

(5) *Higher than in either parent:* In the width of the dorsal sepal ♀ ; width of the labellum ♂ ; length ♂, and width ♂, of the upper epidermal cells of the leaf at the base; width of the lower epidermal cells at the middle of the leaf ♀ = ♂ ; length ♂, width ♂, of the lower epidermal cells at the base of the leaf; depth of the lower epidermal cells ♂, width of the midrib bundle ♂, thickness of leaf at the midrib ♂, on the transverse section of the leaf at the midrib; width of the epidermal cells at the top of the flower-stalk ♂ ; length of the epidermal cells at the middle of the flower-stalk ♂ ; thickness of the outer walls of the epidermal cells ♀ on the transverse section of the flower-stalk at the middle; length ♂, width ♀, of the upper epidermal cells of the dorsal sepal at the midrib; the number of hairs ♀, length of hairs ♀, on the upper epidermis of the dorsal sepal at the midrib; length of the upper epidermal cells at the base of the dorsal sepal ♂ ; length of the hairs ♀ on the upper epidermis at the base of the dorsal sepal; length ♀, width ♂, of the lower epidermal cells at the base of the dorsal sepal; length ♂, width ♀, of the upper epidermal cells at the middle of the petal; length ♂, width ♀, of the lower epidermal cells at the middle of the petal; length of the hairs on the anterior part at the base of the petal ♂ ; width ♂, color ♂, of the upper epidermal cells of the labellum near the base; length of the upper epidermal cells of the labellum at the most anterior part ♀ = ♂ ; length of the lower epidermal cells of the labellum between the apex of the most anterior part ♂ ; length ♀, and width ♀ of the lower epidermal cells at the base of the labellum.

(6) *Lower than in either parent:* In the depth of the cuticle ♂, depth of the upper epidermal cells ♂, depth of the lower cuticle ♀, on the transverse section of the leaf; depth of the epidermal cells ♀ on the transverse section of the flower-stalk; length of the club-shaped hairs ♀, on the lower epidermis of the dorsal sepal at the base; length of the hairs ♀ on the upper epidermis of the labellum near the base; length of the hairs ♂ on the upper epidermis of the labellum at the most anterior part. (Table J 56.)

TABLE J 56.—*Summary of characters of hybrid-stock as regards sameness, intermediateness, excess, and deficit of development in relation to parent-stocks.*

	Macroscopic.	Microscopic.	Total.
Same as seed parent	1	1	2
Same as pollen parent	0	4	4
Same as both parents	2	2	4
Intermediate	29	43	72
Highest	2	30	32
Lowest	0	7	7

COMPARATIVE SUMMARY OF THE CHARACTERS OF THE HYBRID CYPRIPEDIUM LATHAMIANUM INVERSUM AND ITS PARENT-STOCKS.

The hybrid was found to be:

(1) *The same or practically the same as the seed parent:* In the length of the ovary; width of the staminode; length of the lower epidermal cells at the middle of the leaf; shape of the cells and waviness of the walls on the lower epidermis of the petal at the middle.

(2) *The same or practically the same as the pollen parent:* In the amount of shortening of the youngest leaf; width of the anterior sepal; micro number of cortex layers in the transverse section of the flower-stalk at the middle.

(3) *The same or practically the same as both parents:* In the shape of the leaves; thickness of leaves; thickness of the walls of the upper epidermal cells at the middle of the leaf; color of the cells on the lower epidermis at the base of the dorsal sepal.

(4) *Intermediate:* In the length of the leaves ♀; width of the leaves ♀; size of blotches at the base of the leaf ♀; length of spotted area at the base of the leaf ♀; length of the youngest leaf ♂; flowering period ♀; length of the flower-stalk ♂; color of the flower-stalk ♀; length of the bract ♂; color of the ovary ♀; length of the dorsal sepal ♀; ratio of length to width of dorsal sepal; shape of dorsal sepal; color of dorsal sepal; length of anterior sepal ♀; color of anterior sepal; length of lateral petals ♀; width of lateral petals ♂; shape of petals ♂; crisping of dorsal margin of petals ♂; length of labellum ♀; color of the outer surface of labellum ♀; color of interior surface of labellum; shape of staminode ♀; color of staminode ♀; thickness of cell walls ♀; length ♂, width ♀, of the upper epidermal cells of the leaf at the apex; length of the upper epidermal cells of the leaf at the base ♀; width of the lower epidermal cells of the leaf at the apex ♂; length of the lower epidermal cells ♂, and number of stomata ♀, at the base of the leaf; depth of the upper epidermis ♀; depth, and width ♀, of the midrib bundle on the transverse section of the leaf; length of the epidermal cells at the top of the flower-stalk ♂; kind of hairs present ♂, number of hairs ♂, length of pointed hairs ♂, length of club-shaped hairs ♀, and color at the top of the flower-stalk; width of the epidermal cells at the middle of the flower-stalk ♀; length of the pointed hairs ♂, length of the club-shaped hairs ♀, and color ♀ at the middle of the flower-stalk; depth ♀, width ♀, of the epidermal cells, and width of cortex ♂, on the transverse section of the flower-stalk; color of the midrib on the upper surface of the dorsal sepal; ratio of pointed to club-shaped hairs, length of pointed hairs ♀, and color ♀, on the lower epidermis of the dorsal sepal at the midrib; width of the upper epidermal cells at the base of the dorsal sepal ♂; number of hairs ♀, color of the upper epidermis at the base of the dorsal sepal; ratio of pointed to club-shaped hairs, length of pointed hairs ♂, length of club-shaped hairs ♂, and color of hairs, on the lower epidermis at the base of the dorsal sepal; width of the upper epidermal cells ♂, and color at the middle of the petal; color of the upper epidermis at the base of the petal; length of the hairs ♀, and color ♀, of the upper epidermis of the labellum at the base; length of the hairs ♂, and color ♂, of the upper epidermis of the labellum at the most anterior part.

(5) *Higher than in either parent:* In the width of the dorsal sepal ♂; color of the petals ♀; width of the labellum ♀; length ♂, width ♂, of the upper epidermal cells at the middle of the leaf; width ♀, of the upper epidermal cells at the base of the leaf; length ♀, of the lower epidermal cells at the apex of the leaf; width ♀ = ♂ of the lower epidermal cells at the middle of the leaf; width ♀, of the lower epidermal cells at the base of the leaf; depth ♀, and width ♂, of the lower epidermal cells, thickness of leaf ♀, on the transverse section of the leaf at the middle; width ♀, of the epidermal cells at the top of the flower-stalk; proportion of club-shaped hairs present ♀, and number of hairs ♀, on the epidermis of the flower-stalk at the middle; thickness of the outer walls of the epidermal cells in the transverse section of the flower-stalk ♂; length ♀, width ♂, of the upper epidermal cells of the dorsal sepal at the midrib; number of hairs ♂, length of hairs ♂, on the upper epidermis of the dorsal sepal at the midrib; length ♀, of the upper epidermal cells at the base of the dorsal sepal; length of the hairs ♂, on the upper epidermis at the base of the dorsal sepal; length ♂, width ♀, of the lower epidermis at the base of the dorsal sepal; length ♀, of the upper epidermal cells at the middle of the petals; length ♀, and width ♂, of the lower epidermal cells at the middle of the petals; length of the hairs on the anterior part of the petals at the base ♀, length of the upper epidermal cells of the labellum at the base ♀; length ♀ = ♂, and width ♂, of the upper epidermal cells of the labellum at the most anterior part; length ♀, and width ♀, of the lower epidermal cells of the labellum between the apex and the most anterior part; color ♀, of the lower epidermis of the labellum between the apex and the most anterior part; length of the lower epidermal cells at the base of the labellum ♂; color of the lower epidermis at the base of the labellum ♂.

TABLE J 57.—*Summary of characters of hybrid-stock as regards sameness, intermediateness, excess, and deficit of development in relation to parent-stocks.*

	Macroscopic.	Microscopic.	Total.
Same as seed parent	2	3	5
Same as pollen parent	2	1	3
Same as both parents	2	2	4
Intermediate	25	41	66
Highest	3	33	66
Lowest	0	8	8

(6) *Lower than in either parent:* In the number of stomata on the lower epidermis of the leaf at the apex ♂; number of stomata on the lower epidermis of the leaf at the middle ♀; depth of the upper cuticle ♀, depth of

the lower cuticle ♂, on the transverse section of the leaf at the midrib; length of the epidermal cells at the middle of the flower-stalk ♂; length of the club-shaped hairs on the lower epidermis of the dorsal sepal at the midrib ♂; width of the upper epidermal cells at the base of the labellum ♀; width of the lower epidermal cells at the base of the labellum ♀.

7. Macroscopic and Microscopic Characters of Cypripedium villosum, C. insigne maulei, and C. nitans.

(Plate 34, figs. 205, 206, and 207. Tables J, 58 to 62; I, 7 and Summaries, Chart F 8.)

General Descriptions.

(For description of *C. villosum* (seed parent) see page 817.)

Data for the following descriptions were obtained from Veitch (Manual of Orchidaceous Plants, II, 33, 93), Reichenbach (Gardeners' Chronicle, 1878, 389), Engler (Pflanzenreich IV, Th. 50, 95, 74; Floral Magazine, 1861, Table 57), and Sander (Orchid Guide, 45, 41).

C. insigne maulei (*Pollen Parent*).—Leaves linear-ligulate, bifid at the apex, green on upper surface with a few small pale-purple specks on the lower surface at the very base, youngest leaf short, erect, inclosing the base of the flower-stalk. Flower-stalk shorter than the leaves, dark purple and hairy; bract compressed, green with purple dots almost as long as the purple pubescent ovary. Flower, dorsal sepal oval, lateral margins revolute toward the base, apical one bent forwards, apple-green at basal and central area, with many brownish-purple spots arranged more or less regularly along the main veins, white above this green area; anterior sepal ovate, acute, pale yellowish green with a few purple spots arranged in lines over the veins at the base; petals with wavy margin, yellowish-brownish-green with rather dull brownish-purple veins; labellum yellowish green shaded with brown; column yellow with short purple hairs; staminode yellowish with an orange-yellow tubercle at the center.

C. nitens (*Hybrid*).—Leaves linear-oblong, bifid at apex, keeled beneath, green above, dotted below at the base for a short distance with small purple dots, last leaf much shorter than others, erect, sheathing more or less the flower-stalk. Flower-stalk slender, erect, green with many purple hairs; bract compressed, green with a few purple dots at base, inclosing about three-fourths of the purple dotted and hairy greenish ovary. Flower, dorsal sepal apple-green with white margin, rows of spots present over the veins, large and brownish black on the green background and small and purple above this on the white area; anterior sepal yellowish green with 2 rows of purple dots along the 2 median veins, darker than in *C. insigne maulei;* the petals long with wavy margins, yellowish brown with reddish-brown veins and glossy; the labellum yellowish green, shaded with purple-brown, and reddish brown toward the anterior; column short and hairy; staminode yellow with a bright yellow tubercle.

Comparisons of the Macroscopic Characters.

Leaf.

The leaves are longer and wider in *C. villosum* than in *C. insigne maulei,* and shorter and narrower in the *hybrid* than in *either parent.* (Table J 58.)

The leaves of *C. villosum* have, on the lower surface at the base of the leaf, small dull brownish-purple dots. In *C. insigne maulei.* the dots are less numerous, are smaller than in *C. villosum,* and are of paler purple. In *C. nitens* the dots are larger and darker than in *C. insigne maulei,* but not as large as in *C. villosum.* The dotted area extends up the leaf for a much greater distance in *C. villosum* than in *C. insigne maulei* and a little further up in *C. nitans* than in *C. insigne maulei.* (Table J 58.)

In all of the plants the youngest leaf is somewhat shortened, embracing the base of the flower-stalk. In *C. villosum* it is not so much shortened as in *C. insigne maulei,* and though in length in the *hybrid* between the *parents* it is much nearer *C. insigne maulei* than *C. villosum.* The amount of shortening shown by comparing the length of the youngest leaf with the average length of the leaves is much less in *C. villosum,* in which the ratio of the shortened leaf to the average length of the leaves is 4 : 5, than in *C. insigne maulei* in which the ratio is 1 : 2. In the *hybrid* the ratio is 2 : 3, between those of the *parents,* nearly mid-intermediate. (Table J 58.)

C. insigne maulei flowers in December, *C. villosum* in February; the *hybrid* in December, very shortly after *C. insigne maulei.*

Flower-stalk.

The flower-stalk is 1.8μ long in *C. villosum,* 15.5μ in *C. insigne maulei,* and 18.5μ in the *hybrid.*

The *color* of the flower-stalk is grass-green with long purple and colorless hairs in *C. villosum;* dark purple and hairy in *C. insigne maulei;* and pale green in *C. nitens,* duller than in *C. villosum* and with purple hairs. At the top of the flower-stalk is a compressed *bract* which surrounds the base of the ovary. They are pale green with purple spots extending along the veins. It is longer in *C. villosum* than in *C. insigne maulei,* and though between the *parents* in length in the *hybrid,* it is much nearer *C. insigne maulei* than *C. villosum.* It incloses almost the entire ovary in *C. villosum,* not quite as much as in *C. insigne maulei,* and a little more than half in the *hybrid.* (Table J 58.)

The *ovary* is also longer in *C. villosum* than in *C. insigne maulei,* and longer in the *hybrid* than in *either parent.* (Table J 58.)

The *color* of the ovary is pale green with a few purple specks and many long purple hairs in *C. villosum;* purple and hairy in *C. insigne maulei;* and green with purple dots and hairs in the *hybrid.*

The *dorsal sepal* is a little longer and wider in *C. villosum* than in *C. insigne maulei,* and larger in both dimensions in the *hybrid* than in *either parent.* (Table J 58.)

In *C. villosum* the *color* of the entire base of the dorsal sepal is a deep red-brown, running up along the veins to the middle of the sepal; the rest, except for a narrow white margin, is a rather deep shade of green. In *C. insigne maulei* it is apple-green at the basal and central parts, with dull brownish-purple spots arranged more or less regularly along the main veins; upper portion white. In *C. nitens* it is a deeper green than in *C. insigne maulei,* but the color does not extend so far up and the spots are of a darker brownish-purple, and arranged more regularly along the main veins; upper half white.

The *anterior sepal* is longer and wider in *C. villosum* than in *C. insigne maulei.* In the *hybrid* the length

is identical with that of *C. villosum,* but the width is greater than in *either parent.* (Table J 58.)

In *C. villosum* the *color* of the anterior sepal is yellowish green with two narrow lines of brownish purple extending along the 2 median veins. In *C. insigne maulei* it is pale yellowish green with a few purple spots arranged in lines at the base. In *C. nitens* it is yellowish green, more greenish than in *C. insigne maulei* and more yellowish than in *C. villosum,* with 2 rows of purple dots over the veins at the base of a deeper purple than in *C. insigne maulei.*

The *lateral petals* are longer and wider in *C. villosum* than in *C. insigne maulei.* In the *hybrid* the length is greater than in *either parent,* the width is between those of the *parents,* but nearer *C. villosum.* (Table J 58.)

TABLE J 58.

	C. villosum.	C. insigne maulei.	C. nitens.
Size of leaves:	*cm.*	*cm.*	*cm.*
Length	27.6	25.3	20.9
Width	3.2	2.8	2.6
Length of purple-spotted area at base of leaf	7 to 7.5	2 to 2.5	2 to 3.5
Length of youngest leaves inclosing flower-stalk	21	12.8	14.1
Length of bract at base of ovary	5.3	4.2	4.3
Length of ovary of flower	5.5	4.7	5.8
Length and width of dorsal sepal:			
Length	6.1	6	6.3
Width	3.5	3.2	4.4
Length and width of anterior sepal:			
Length	5.8	5.3	5.8
Width	2.5	2.2	2.8
Length and width of lateral petals:			
Length	6.8	5.8	7
Width	3	1.6	2.5
Length and width of labellum:			
Length	6	4.5	5.5
Width	3	2.5	3.1

In *C. villosum* the petal is very much narrower at the base than toward the apex, the apical width being about three times the basal width. In *C. insigne maulei* the apical width is greater than the basal width, but not so great as in *C. villosum.* In the *hybrid* the dimensions are between those of the *parents,* the apical width being over twice the basal width.

In *C. villosum* both margins are undulating; in *C. insigne maulei,* the dorsal margin is crisped, the ventral wavy; and in the *hybrid* the dorsal margin is crisped but not so much as in *C. insigne maulei.* While the *hybrid* is between the parents in regard to this character, it appears to be nearer *C. insigne maulei* than *C. villosum.*

In *C. villosum* the petals are distinctly divided into halves by the mid-line of reddish purple-brown. The upper half is a darker brown, the lower half more greenish. The upper surface is hairy at the base. In *C. insigne maulei* the petals are all yellowish-brownish-green, with rather dull brownish-purple veins, the median vein being somewhat more prominent at the base, where hairs are present. In the *hybrid* the petals are glossy yellowish-brown, with deeper brownish-red veins, especially the median veins which are darker at the base. Hairs are present at the base.

The *labellum* is longer and wider in *C. villosum* than in *C. insigne maulei.* In the *hybrid* it is between the parents in length, but nearer *C. villosum,* and greater than in *either parent* in width. (Table J 58.)

The *color* of the outer surface of the labellum in *C. villosum* is yellowish green at the base, becoming brownish yellow anteriorly. In *C. insigne maulei* it is paler green at the base, becoming pale brownish green anteriorly, with slightly darker veins. In the *hybrid* it is greenish yellow at the base (more yellowish than in *C. insigne maulei,* and not as green as in *C. villosum*), becoming greenish brown anteriorly, with brownish-violet veins.

The *color* of the *inside of the labellum* in *C. villosum* is at the base pale yellow with purple hairs and red-purple dots over the veins, becoming anteriorly greenish with a faint suggestion of brownish violet. In *C. insigne maulei* it is yellow at the base, with purple hairs and a few dots over the veins, becoming brownish yellow anteriorly. In the *hybrid* it is pale yellow-green at the base, with purple hairs and red-purple dots over the veins, becoming brownish-greenish-violet anteriorly, slightly darker than in *C. villosum,* and with somewhat greenish veins.

The *staminode* is shield-shaped in all three plants, the only difference in shape being that *C. insigne maulei* does not have such a prominent apex as in *C. villosum* and the *hybrid.* In this character the *hybrid* is exactly like the seed parent *C. villosum.* The size of the staminode is also identical in the *hybrid* and *C. villosum,* that of *C. insigne maulei* being smaller.

The width of staminode of *C. villosum* is 1.4 cm., of *C. insigne maulei* is 1.1 cm., of *C. nitens* 1.4 cm.

In *color* the staminode in *C. villosum* is olive-green, with short purple hairs, and greenish tubercle; in *C. insigne maulei,* yellow, with purple hairs, and yellow tubercle; in the *hybrid,* orange-brown, with purple hairs, and a deeper yellow tubercle than in *C. insigne maulei.*

COMPARISONS OF THE MICROSCOPIC CHARACTERS.

LEAF.

Sections of the *upper epidermis* were taken at the apex, middle, and base of leaves of the same age. At the *apex,* the upper epidermal cells are hexagonal in shape, with a thick cuticle. The cell walls are thicker in *C. villosum* than in *C. insigne maulei,* and fairly mid-intermediate in thickness in the *hybrid.* The cells are only slightly longer and narrower in *C. villosum* than in *C. insigne maulei,* and smaller in the *hybrid* than in *either parent.* (Table J 59.)

At the *middle* of the leaf the cell walls are practically identical in thickness in all three plants. The cells are longer but narrower in *C. villosum* than in *C. insigne maulei;* and in the *hybrid* between those of the *parents* in length, but very much nearer *C. villosum,* while in width they are less than in *either parent,* being slightly narrower than and much closer to *C. villosum.* (Table J 59.)

At the *base* of the leaf the cells of *C. villosum* are larger than those of *C. insigne maulei.* In the *hybrid* the size is between those of the *parents,* though much nearer those of *C. insigne maulei* than *C. villosum.* (Table J 59.)

The average size of the upper epidermal cells of the whole leaf is greater in *C. villosum* than in *C. insigne maulei.* Those of the *hybrid* are narrower than in *either*

parent, and while in length between those of the *parents* they are nearer those of *C. insigne maulei* than of *C. villosum.* (Table J 59.)

Sections of the *lower epidermis* from the *apex, middle,* and *base* of the leaf were examined. At the *apex* the cells are somewhat hexagonal or elongated hexagonal, with rather thick walls and a thick cuticle. They are larger in *C. villosum* than in *C. insigne maulei,* and larger in the *hybrid* than in *either parent.* (Table J 59.)

Stomata are present on the lower epidermis—9.2 in *C. villosum,* 13.2 in *C. insigne maulei,* and 9.1 in *C. nitens.*

The *lower epidermal cells* at the *middle* of the leaf are larger in *C. villosum* than in *C. insigne maulei,* and between those of the *parents* in the *hybrid,* though nearer *C. insigne maulei* in length and almost identical with *C. villosum* in width. (Table J 59.)

Stomata are less numerous in *C. villosum* (7.7) than in *C. insigne maulei,* and between the *parents* in the *hybrid,* but nearer *C. villosum.*

The number of stomata in the lower epidermis at the middle of the leaf is *C. villosum* 7.7, *C. insigne maulei* 11.6, *C. nitens* 8.4.

The *lower epidermal cells* at the *base* of the leaf are elongated hexagonal, with thick walls and a thick cuticle. They are larger in *C. villosum* than in *C. insigne maulei,* and between those of the *parents* in the *hybrid,* being nearer *C. villosum* in length and *C. insigne maulei* in width. (Table J 59.)

Stomata are absent in the lower epidermis at the base of the leaf.

The average size of the lower epidermal cells for the *whole leaf* is greater in *C. villosum* than in *C. insigne maulei.* In the *hybrid,* while between those of the *parents,* it is nearer *C. villosum* than *C. insigne maulei.*

In *C. villosum,* at the base of the leaf on the lower surface, are dull brownish-purple dots, due to 5 or 6 grouped cells being filled with a red-purple sap. In *C. insigne maulei* there are a very few pale purple specks, due to a few single scattered cells that contain a dull purple sap. In *C. nitens* the dots are larger and darker than in *C. insigne maulei,* due to a dull purple sap in a few grouped cells.

Transverse sections of leaves of the same age were taken at a point *midway between the apex and the base.* The upper epidermal cells have on their outer surface a layer of wax. The cuticle and layer of wax are thicker in *C. villosum* than in *C. insigne maulei,* and narrower in the *hybrid* than in *either parent.* The epidermal cells, elongated in depth to form an aqueous tissue, are not as deep in *C. villosum* as in *C. insigne maulei,* and not as deep in the *hybrid* as in *either parent.* (Plate 34, figs. 203, 205, 206, and 207. Table J 59.)

The lower epidermal cells directly beneath the *midrib bundle* were compared as to thickness of outer wall and size. The outer wall (cuticle and wax) is thicker in *C. villosum* than in *C. insigne maulei,* and not as thick in the *hybrid* as in *either parent.* The cells of *C. villosum* are deeper but not as wide as those of *C. insigne maulei.* In the *hybrid* they are deeper and narrower than in *either parent.* (Table J 59.)

Between the elongated upper epidermal cells and the lower epidermal cells are several layers of small, rounded, chlorophyll-containing cells in which are embedded the midrib bundle. The *midrib bundle* is larger in *C. villosum* than in *C. insigne maulei,* but deeper and wider in the *hybrid* than in *either parent,* though the depth is only a very little greater in the *hybrid* than in *C. villosum.* (Table J 59.)

The thickness of the transverse sections at the region of the *midrib* was also compared in the three plants. The leaf was found to be thicker in *C. villosum* than in *C. insigne maulei,* and between the two in the *hybrid,* though nearer *C. villosum* than *C. insigne maulei.* (Table J 59.)

TABLE J 59.

	C. villosum.	C. insigne maulei.	C. nitens.
Length and width of cells of upper epidermis at apex of leaf:	μ	μ	μ
Length	105.5	104	99.7
Width	84.6	89.6	79.2
Length and width of cells of upper epidermis at middle of leaf:			
Length	144.3	132.5	143.3
Width	109.1	111.2	108.7
Length and width of cells of upper epidermis at base of leaf:			
Length	150.1	139.3	142.2
Width	85.3	65.5	68
Length and width of cells of upper epidermis of whole leaf:			
Length	133.3	125.3	128.4
Width	93	88.8	85.3
Length and width of cells of lower epidermis at apex of leaf:			
Length	77.7	71.3	87.8
Width	50.7	45	51.5
Length and width of cells of lower epidermis at middle of leaf:			
Length	87.1	74.5	78.1
Width	57.6	49.3	57.2
Length and width of cells of lower epidermis at base of leaf:			
Length	110.1	88.5	102.9
Width	65.1	54.7	55.8
Size of cells of lower epidermis for entire leaf:			
Length	91.6	78.1	89.6
Width	57.8	49.7	54.8
Cells of upper epidermis in transverse section:			
Depth of cuticle and wax	27	24.8	22.3
Depth of upper epidermal cells	363.6	407.5	232.9
Cells of lower epidermis beneath midrib bundle in transverse section:			
Depth of outer wall	28.8	21.9	18.7
Depth of lower epidermal cells	29.9	27.7	30.9
Width of lower epidermal cells	36.7	37.8	33.8
Depth and width of midrib bundle in transverse section:			
Depth	369	306	370.1
Width	236.9	212.4	262.1
Thickness of transverse section at midrib	1,738.2	1,475.5	1,679.1

FLOWER-STALK.

Sections of the epidermis of the flower-stalk were taken just below the ovary and at a point midway between the ovary and the base of the flower-stalk. Just *below the ovary* the cells are rectangular, with rather thin, lateral walls and a thick cuticle on the outer surfaces. The cells are larger in *C. villosum* than in *C. insigne maulei,* and are shorter in the *hybrid* than in *either*

parent, and intermediate in width between the *parents,* but nearer *C. insigne maulei.*

Both *pointed and club-shaped hairs* are present at the top of the flower-stalk. Equal numbers of pointed and club-shaped hairs are present in *C. villosum;* 2 pointed to 1 club-shaped in *C. insigne maulei;* and in the *hybrid* almost exactly mid-intermediate in proportions between those of the *parents.* There are 3 hairs in a field in *C. villosum,* 5.1 in *C. insigne maulei,* and 4 in *C. nitens.* The pointed hairs are longer in *C. villosum* than in *C. insigne maulei,* and in the *hybrid* between those of the *parents* in length, but nearer *C. insigne maulei* than *C. villosum.* The club-shaped hairs are longer in *C. villosum* than in *C. insigne maulei,* and in the *hybrid* very nearly identical with those of *C. villosum.* (Table J 60.)

The *color* at the top of the flower-stalk in *C. villosum* is green, with many purple and colorless hairs, due to some cells containing green plastids and to others with a violet sap and yellow chromoplasts. The hairs all contain yellow chromoplasts which become orange-brown in the end cells. Nearly all of the hairs contain a deep-violet sap. In *C. insigne maulei* the color is purple, with many hairs, due to all the cells (except those from which hairs arise) being filled with deep-violet cell sap. Yellow chromoplasts appear to be present in these cells. The hairs are filled with violet sap, so deep in color as to appear almost black; yellow-orange and orange-brown chromoplasts are present especially in the end cells. In the *hybrid* the color both macroscopically and microscopically is very nearly the same as in *C. villosum.*

The *epidermis* at the *middle* of the flower-stalk consists of thin, lateral-walled, rectangular cells having a thick outer cuticle. They are larger in *C. villosum* than in *C. insigne maulei,* and are shorter and wider in the *hybrid* than in *either parent.* (Table J 60.)

Hairs similar to those at the top of the flower-stalk are present at the *middle.* Pointed hairs are twice as numerous as the club-shaped in both *C. villosum* and *C. insigne maulei,* but are a little more numerous than the club-shaped ones in the *hybrid* than in *either parent.* The hairs in a field number 3.1 in *C. villosum,* 5.2 in *C. insigne maulei,* and 4.8 in *C. nitens.* The pointed hairs are longer in *C. villosum* than in *C. insigne maulei,* and in the *hybrid* between those of the *parents* but nearer those of *C. insigne maulei.* The club-shaped hairs also are longer in *C. villosum* than in *C. insigne maulei,* but are shorter in the *hybrid* than in *either parent.* (Table J 60.)

The *color* is the same at both middle and top of the flower-stalk.

Transverse sections of the flower-stalk were made at a point *midway between the top and the base.* Outermost is a layer of rounded epidermal cells with slightly thickened inner and lateral walls, and with a greatly thickened outer wall. The outer wall is ridged in all three plants, but is not as thick in *C. villosum* as in *C. insigne maulei.* In the *hybrid* the thickness is identical with that of *C. insigne maulei.* From this layer the hairs arise. The cells themselves are larger in *C. villosum* than in *C. insigne maulei,* and between those of the *parents* in size in the *hybrid,* the depth being nearer *C. villosum* and the width mid-intermediate. (Table J 60.)

Beneath the epidermis is a *zone of cortex,* consisting of several layers of rounded, thin-walled, chloroplast-containing cells, the outer layer of which is thicker-walled. There are 10 to 12 layers in *C. villosum,* and 9 to 10 in *C. insigne maulei* and in the *hybrid.* The *cortex* is much wider in *C. villosum* than in *C. insigne maulei;* and between the *parents* in width in the *hybrid,* but much nearer *C. insigne maulei.* (Table J 60.)

TABLE J 60.

	C. villosum.	C. insigne maulei.	C. nitens.
Length and width of cells of upper epidermis at top of flower-stalk:	μ	μ	μ
Length	123.8	107.3	103.7
Width	52.9	42.8	45.7
Length of hairs at top of flower-stalk:			
Length of pointed hairs	1,534.7	447.2	913.5
Length of club-shaped hairs	407.1	252.3	405.4
Length and width of cells of epidermis of middle of flower-stalk:			
Length	143.6	119.1	114.1
Width	55.8	41.4	56.9
Number and length of hairs at middle of flower-stalk:			
Length of pointed hairs	1,216.2	558.5	638.6
Length of club-shaped hairs	450.6	379.3	266.2
Thickness, depth, and width of cells of outer epidermis of transverse section at middle of flower-stalk:			
Thickness of outer wall	9 to 10.8	14.4 to 18	14.4 to 18
Depth of cells	67.7	56.5	64.8
Width	47.9	37.4	42.8
Width of cortex of transverse section at middle of flower-stalk	54	37.8	41.4

FLOWER.

Sections of the *upper epidermis* of the *dorsal sepals* of the three plants were made at the *median point* along the *midrib.* The upper epidermal cells are wavy-walled, and are smaller in *C. villosum* than in *C. insigne maulei,* and larger in the *hybrid* than in *either parent.* No *hairs* are present on the upper epidermis. (Table J 61.)

The *color* of this region is pea-green, with dark-brown veining in *C. villosum;* light green with dull brownish-purple spots in *C. insigne maulei;* and a darker green with darker brownish-purple spots in the *hybrid.* It is due in *C. villosum* to the presence of green plastids in the upper epidermal cells, and to a red-violet cell sap in the layer beneath; in *C. insigne maulei* to yellow-green plastids in the upper epidermal cells and a red-violet sap (at the region of the spots) in the layer beneath; in the *hybrid,* to yellowish-green plastids in the upper epidermal cells and to red-violet cell sap (over the spots) in the layer beneath, the color being slightly deeper than that of *C. insigne maulei.* Above the green area in *C. insigne maulei* and in the *hybrid* yellowish-green plastids only are present.

Sections of the *lower epidermis* were taken along the *midrib* at the *middle* of the *dorsal sepal. Hairs,* both the pointed and the club-shaped, are very numerous. The club-shaped hairs are relatively more numerous (1 to 4) in *C. villosum,* but the pointed hairs are relatively more numerous (7 to 1) in *C. insigne maulei;* both are present in practically the same numbers in the *hybrid.* The pointed hairs are very much longer in *C. villosum* than in

C. insigne maulei, and shorter in the *hybrid* than in *either parent*. The club-shaped hairs are also longer in *C. villosum* than in *C. insigne maulei*, and while in length between those of the *parents*; in the *hybrid*, they are nearer those of *C. villosum*. (Table J 61.)

The *color* in *C. villosum* is green, with long purple hairs; in *C. insigne maulei*, yellowish, hairy, with a few purple hairs; in the *hybrid*, green, hairy, with a few purple hairs. The color in *C. villosum* is due to the epidermal cells being filled with yellowish-green plastids, the hairs filled with a red-violet cell sap and yellowish-green plastids, and the end cells of the blunt hairs being packed with yellow-brown chromoplasts; in *C. insigne maulei* and the *hybrid*, to the cells being filled with yellow chromoplasts, a few hairs containing a red-violet cell sap, and others having very few yellow chromoplasts.

Sections of the *upper epidermis* at the *base* of the *dorsal sepal* were examined. The upper epidermal cells are smaller in *C. villosum* than in *C. insigne maulei*. Those of the *hybrid* are longer than in *either parent*, and in width identical with *C. insigne maulei*. (Table J 61.)

The *color* in *C. villosum* is a deep reddish brown; in *C. insigne maulei* a pale green with dull brown-purple spots; and in the *hybrid* a slightly darker green with darker brown-purple spots. It is due in *C. villosum* to the upper epidermal cells containing many greenish-yellow chromoplasts, and to many cells of the layer beneath being filled with a red-violet cell sap; in *C. insigne maulei*, to a few yellowish-green plastids in the upper epidermal cells, and to a red-violet cell sap beneath the spots in the layer beneath the upper epidermis; and in the *hybrid* to yellowish-green plastids and a red-violet cell sap in the layer beneath, the red-violet being slightly more red than in *C. insigne maulei*.

The *lower epidermis* at the *base* of the *dorsal sepal* consists of shorter and wider cells in *C. villosum* than in *C. insigne maulei*. In the *hybrid* the average length is much greater than in *either parent*, and the width between those of the *parents* but nearer *C. villosum*. (Table J 61.)

Both pointed and club-shaped hairs are present. The club-shaped hairs are more numerous than the pointed hairs (2 to 1) in *C. villosum*, the latter being very rare. The pointed hairs are twice as numerous as the club-shaped hairs in *C. insigne maulei*. The club-shaped hairs are more numerous than the pointed ones in the *hybrid*, the ratio being between those of the *parents*. Both pointed and club-shaped hairs are longer in *C. villosum* than in *C. insigne maulei*, and while the average length in the *hybrid* is between those of the *parents* it is much nearer those of *C. insigne maulei*. (Table J 61.)

The *color* in *C. villosum* is green, with long violet green (not as deep as in *C. villosum*), with violet hairs, and a purple blotch at base; and in the *hybrid*, deeper green (not as deep as in *C. villosum*), with violet hairs, and a smaller purple blotch at the base. The color, in *C. villosum*, is due to the epidermal cells being filled with yellowish-green plastids, and to all the hairs containing a violet cell sap with a few yellowish chromoplasts; in *C. insigne maulei*, to the epidermal cells being filled with yellowish-green plastids, a red-violet cell sap present in the layer beneath (at the region of the blotch), a red-violet cell sap in the pointed hairs, end cell of club-shaped hairs being filled with orange-yellow chromoplasts; in the *hybrid*, to the same causes as in *C. insigne maulei*, except that there are fewer cells in the layer beneath which contain a red-violet sap, a few grouped cells containing the sap rather than all of the cells as in *C. insigne maulei*.

The *upper epidermis* of the *lateral petal* along the *median line* is composed of cells with thin, wavy walls. They are smaller in *C. villosum* than in *C. insigne maulei*, and larger in the *hybrid* than in *either parent*. (Table J 61.)

The *color* above the midrib in *C. villosum* is a deep red-brown, due to the presence of yellow chromoplasts in the upper epidermal cells, and to a red-violet sap in the layer beneath; in *C. insigne maulei*, greenish-yellowish-brown with pale purplish-brown veins, and due to yellow chromoplasts in the upper epidermal cells and (where the pale purplish-brown veins are present) to a pink-violet sap that fills the cells of the layer beneath; in the *hybrid*, yellowish brown, with deeper red-brown veins, and due to greenish-yellow chromoplasts in the upper epidermal cells and (where the red-brown veins are present) to a pink-violet sap that fills the cells of the layer beneath, the sap being slightly deeper in color than in *C. insigne maulei*.

The *lower epidermis* of the *petal* at the *same region* consists of cells which have thin wavy walls. They are longer and broader in *C. villosum* than in *C. insigne maulei*, and shorter and wider in the *hybrid* than in *either parent*. (Table J 61.)

A few *hairs* are present along the midrib region.

Sections of the *upper epidermis*, of the *anterior half* at the *base of the petal*, show long pointed *hairs* which are longer in *C. villosum* than in *C. insigne maulei*, and are slightly longer in the *hybrid* than in *either parent*. (Table J 61.)

The *color* in *C. villosum* is greenish yellow, with violet hairs, and pale brown-purple specks, due to a few pale yellow chromoplasts in the upper epidermal cells and hairs, and to a red-violet sap in the hairs and in a few of the cells of the layer beneath the epidermis; in *C. insigne maulei*, yellow, with violet hairs, due to a few yellow chromoplasts in the cells and hairs, and to a deep red-violet sap in the hairs; in the *hybrid*, pale yellowish-green, with violet hairs, due to pale greenish-yellow chromoplasts in cells and hairs, and to a red-violet sap in the hairs and in a few patches of cells in the layer beneath the epidermis.

Sections of the *inner epidermis* of the *labellum* were taken at the *base* along the *mid-line*. The cells are somewhat irregular in shape, with thin wavy walls. They are larger in *C. villosum* than in *C. insigne maulei*, and longer and narrower in the *hybrid* than in *either parent*. (Table J 61.)

Numerous long pointed *hairs* are present. They are longer in *C. villosum* than in *C. insigne maulei*, and longer in the *hybrid* than in *either parent*. (Table J 61.)

The *color* of this area of the labellum is in *C. villosum* pale yellow, with purple hairs, and red-violet dots over the veins, due to the upper epidermal cells containing a few yellow chromoplasts, and to areas of many cells containing a deep red-violet sap. The short hairs contain yellow chromoplasts; the long hairs a red-violet sap and yellow chromoplasts. In *C. insigne maulei* the same area is yellow, with purple hairs, and a few faint purple

dots over the veins. Under the microscope coloration is found to be due to the same causes as in *C. villosum*, except that the clusters of cells containing red-violet sap consist of fewer cells, are less numerous, and further apart. In the hybrid the area is pale yellowish green, with purple hairs, and red purple dots over the veins, the color being deeper than in *C. villosum*, and the area larger than in *C. insigne maulei*. The appearance under the microscope is similar to that in *C. insigne maulei*, but there is a greater number of cells in the area that contain red-violet sap.

Sections of the *inner epidermis* at the most *anterior part* of the *labellum* along the *mid-line* were examined in the three plants. The upper epidermal cells are very wavy-walled and smaller in *C. villosum* than in *C. insigne maulei*, and larger in the *hybrid* than in *either parent*. (Table J 61.)

Long *hairs* are present in this region. They are shorter in *C. villosum* than in *C. insigne maulei*, and shorter in the *hybrid* than in *either parent*. (Table J 61.)

The *color* in *C. villosum* is pale brownish-greenish-violet, with purple hairs, due to many cells being filled with lavender sap and yellow chromoplasts, and to a few cells with yellow chromoplasts only. Hairs mostly contain a pale-violet sap and yellow chromoplasts; a few contain orange or brown chromoplasts only. In *C. insigne maulei* the color is yellowish brown, with purple hairs, due to the cells containing yellow chromoplasts, the hairs containing yellow chromoplasts and a pale-violet cell sap, or with orange and orange-brown chromoplasts only. In the *hybrid* the color is brownish-greenish-violet, darker than in *C. villosum*, with purple hairs, due to many cells containing a lavender sap and yellow chromoplasts, and to a few cells with yellow chromoplasts only. Hairs containing a pale-violet sap and yellow chromoplasts are more numerous than in *C. insigne maulei*, and only a few contain only orange or brown chromoplasts.

Sections of the *lower epidermis* of the *labellum* were taken *between the apex and the most anterior point* (between the top of the slipper and the toe). The cells are all large and very wavy-walled. They are a little smaller in *C. villosum* than in *C. insigne maulei*, and larger in the *hybrid* than in *either parent*. (Table J 61.)

The *color* of this region in *C. villosum* is brownish green with brownish-violet veins, due to some cells containing only yellow chromoplasts, and to others with a pale-lavender sap and yellow chromoplasts. In *C. insigne maulei* the color is yellow with brownish-violet veins, darker than in *C. villosum*, and due to a pale-lavender cell sap and yellow chromoplasts in some cells, and to yellow chromoplasts only in other cells. In the *hybrid* the color is brownish green with brownish-violet veins, very similar to *C. villosum*, but darker, the brownish-violet veins being not so dark as in *C. insigne maulei*; the cell sap is darker than in *either parent*, and nearer a red-violet than a lavender. Some of the cells contain both yellow chromoplasts and colored sap, and others only yellow chromoplasts.

Sections of the *lower epidermis* were also taken at the *base* of the *labellum* along the *mid-line*. The cells are large and have thin, wavy walls. They are smaller in *C. villosum* than in *C. insigne maulei*, and larger in the *hybrid* than in *either parent*. (Table J 61).

TABLE J 61.

	C. villosum.	C. insigne maulei.	C. nitens.
Length and width of cells of upper epidermis at middle of dorsal sepal:	μ	μ	μ
Length	106.5	127.4	129.6
Width	59.7	77	91.4
Length of hairs on lower epidermis at midrib of dorsal sepal:			
Length of pointed hairs	1,430.3	508.1	483.7
Length of club-shaped hairs	581.1	278.4	473.3
Length and width of cells of upper epidermis at base of dorsal sepal:			
Length	99.3	111.6	124.5
Width	67.7	72.7	72.7
Length and width of cells of lower epidermis at base of dorsal sepal:			
Length	79.9	85.7	108
Width	57.6	41.4	50.7
Length of hairs on lower epidermis at base of dorsal sepal:			
Length of pointed hairs	1,658.2	457.6	490.7
Length of club-shaped hairs	1,106.6	332.3	464.6
Length and width of cells of upper epidermis at middle of lateral petal:			
Length	105.1	113	125.6
Width	54	70.5	72.3
Length and width of cells of lower epidermis at middle of lateral petal:			
Length	119.1	104.7	101.9
Width	64.8	61.2	67.7
Length of hairs on upper epidermis, anterior half at base of petal	1,578.2	1,214.5	1,595.6
Length and width of cells of upper (inner) epidermis at base of labellum along mid-line:			
Length	112.7	111.9	117.3
Width	65.5	64.1	63.7
Length of hairs on upper (inner) epidermis at base of labellum along mid-line	1,278.9	1,160.6	1,346.7
Length and width of cells of upper (inner) epidermis at most anterior part of labellum along mid-line:			
Length	88.2	94.3	112.3
Width	50	56.1	62.6
Length of hairs on inner surface of labellum at most anterior part along mid-line	612.5	763.8	582.9
Length and width of cells of lower epidermis of labellum between apex and most anterior part:			
Length	122.7	123.1	133.2
Width	74.1	77.4	83.1
Length and width of cells of lower epidermis at base of labellum along mid-line:			
Length	99	102.9	106.5
Width	65.5	66.2	68.4

The *color* of this area in *C. villosum* is yellowish green (more greenish than in the *hybrid*), due to the presence of a few pale-yellow chromoplasts in the cells; in *C. insigne maulei* greenish yellow; in the *hybrid* greenish yellow (more yellowish than in *C. insigne maulei*), to yellow chromoplasts in the cells.

Comparative Summary of the Characters of the Hybrid Cypripedium nitens and its Parents.

The hybrid was found to be:

(1) *The same or practically the same as the seed parent:* In the color of the flower-stalk; length of the

anterior sepal; length of the apex of the staminode; width of the staminode; number of stomata on the lower epidermis of the leaf at the apex; width of the lower epidermal cells of the leaf at the middle; length of the club-shaped hairs and color at the top of the flower-stalk; color of the upper epidermis at the most anterior part of the labellum.

(2) *The same or practically the same as the pollen parent:* In the length of the bract; thickness of the outer walls of the epidermis, number of layers in the cortex in the transverse section of the flower-stalk; color of the lower epidermis of the dorsal sepal at the middle; width of the upper epidermal cells of the dorsal sepal at the base.

(3) *The same or practically the same as in both parents:* In the shape of upper epidermal cells of the leaf; thickness of cell walls of the upper epidermis of the leaf at the middle; shape of the lower epidermal cells of the leaf; absence of stomata on the lower epidermis of the leaf at the base; shape of cells, thickness of walls of the upper epidermis at the top of the flower-stalk; shape of the cells of the epidermis of the flower-stalk on transverse sections.

(4) *Intermediate:* In the size of the blotches at the base of the leaf; length of the spotted area ♂; length of the youngest leaf ♂; amount of shortening of the youngest leaf; flowering period ♂; color of ovary; color of the dorsal sepal ♂; color of anterior sepal; width of lateral petals ♀; shape of petals; crisping of margin of petals ♂; color of petals; length of labellum; color of exterior of labellum; color of interior of labellum; thickness of cell walls of the upper epidermis of the leaf at the apex; length ♀, of the upper epidermal cells of the leaf at the middle; length ♂, width ♂, of the upper epidermal cells of the leaf at the base; length of the lower epidermal cells of the leaf at the middle ♀; number of stomata on the lower epidermis of the leaf at the middle ♀; length ♀, width ♂, of the lower epidermal cells, and color at the base of the leaf; thickness of the transverse section of the leaf at the midrib ♀; width of the upper epidermal cells of the flower-stalk at the top ♂; ratio of pointed to club-shaped hairs, number of hairs, length of pointed hairs ♂, on the epidermis at the top of the flower-stalk; number of hairs ♂, length of pointed hairs ♂, on the epidermis at the middle of the flower-stalk; depth ♀, and width ♀ of the epidermal cells, width of the cortex ♂, in the transverse section of the flower-stalk; color of the dorsal sepal at the middle ♂; ratio of pointed to club-shaped hairs ♀, and length of club-shaped hairs on the lower epidermis of the dorsal sepal at the middle; color of the upper epidermis of the dorsal sepal at the base; width of the lower epidermal cells of the dorsal sepal at the base ♀; ratio of pointed to club-shaped hairs and color of the lower epidermis of the dorsal sepal at the base; color of the upper epidermis of the lateral petals at the middle ♂; color of the upper epidermis of the lateral petals at the base ♀; color of the upper epidermis of the labellum at the base along the midline ♂.

(5) *Higher than in either parent:* In the length of flower-stalk ♀; length of ovary ♀; length ♀, and width ♀ of dorsal sepal; width of the anterior sepal ♀; length of the lateral petals ♀; width of labellum ♀; color of staminode ♂; length ♀, and width ♀, of the lower epidermal cells at the apex of the leaf; depth of the lower epidermal cells ♀, depth ♀, and width ♀, of the midrib bundle in the transverse section of the leaf; width of the upper epidermal cells at the middle of the flower-stalk ♀; ratio of pointed to club-shaped hairs at the middle of the flower-stalk ♀=♂; length ♂, width ♂, of the upper epidermal cells of the dorsal sepal at the middle; length ♂, of the upper epidermal cells of the dorsal sepal at the base; length ♂, of the lower epidermal cells of the dorsal sepal at the base; length ♂, width ♂, of the upper epidermal cells at the middle of the lateral petals; width ♀, of the lower epidermal cells at the middle of the lateral petals; length of hairs ♀, at the base of the labellum along the midline; length ♂, width ♂, of the upper epidermal cells at the most anterior part of the labellum along the midline; length ♂, width ♂, of the lower epidermal cells, and color of sap ♂, in these cells between the apex and the most anterior part of the labellum; length ♂, width ♂, of the lower epidermal cells at the base of the labellum along the midline.

(6) *Lower than in either parent:* In the length of the leaves ♂, width of leaves ♂; length ♂, width ♀, of the upper epidermal cells of the leaf at the apex; width ♀ of the upper epidermal cells of the leaf at the middle; depth of cuticle ♂, depth of upper epidermal cells ♀; depth of lower cuticle ♂, width of lower epidermal cells ♀, in the transverse section of the leaf at the midrib; length of the epidermal cells at the top of the flower-stalk ♂; length of the epidermal cells ♂, length of club-shaped hairs ♂ at the middle of the flower-stalk; length of pointed hairs on the lower epidermis of the dorsal sepal at the middle ♂; epidermis of the labellum at the most anterior part ♀.

TABLE J 62.—*Summary of characters of hybrid-stock as regards sameness, intermediateness, excess, and deficit of development in relation to parent-stocks.*

	Macroscopic.	Microscopic.	Total.
Same as seed parent	4	5	9
Same as pollen parent	1	4	5
Same as both parents	0	7	7
Intermediate	15	29	44
Highest	8	24	32
Lowest	12	14	16